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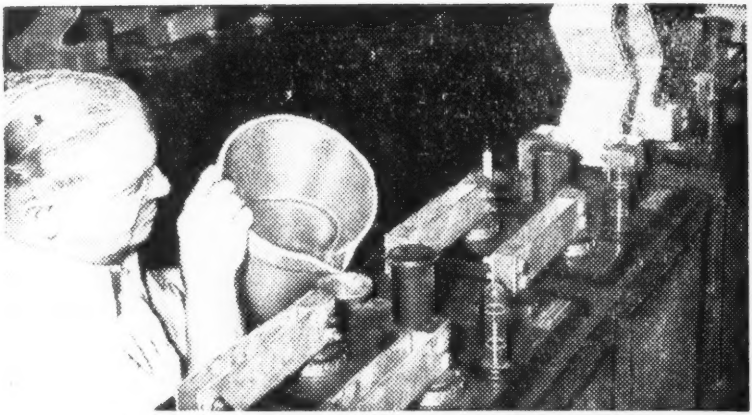
The American Society for Engineering Education



At the New York Telephone Company's Triangle exchange in Brooklyn, emergency batteries stand ready to deliver 3000 amperes for several hours.

How a whiff of stibine led toward lower telephone costs

In the Bell System there are a million lead storage battery cells connected to telephone circuits in the central offices. Current seldom flows in or out of these cells beyond the trickle which keeps them charged. If power fails, they stand ready to supply the current for your telephone service.

Even in this stand-by service, cells require water to make up for electrolysis. And they consume power and eventually wear out. But Bell Laboratories chemists discovered how to make a battery which lasts many more years and requires less attention—by changing a single ingredient, the clue to which came unexpectedly from another line of their research.

The clue was a minute trace of stibine gas in battery rooms which electrochemists detected while on the lookout for atmospheric causes of relay contact corrosion. In small traces the gas wasn't harmful but to battery chemists it offered a powerful hint.

For stibine is a compound of antimony—and antimony is used to harden the lead grids which serve as mechanical supports for a battery's active materials. Tracing the stibine, the chemists discovered that antimony is leached out of the positive grid and enters into chemical reactions which hasten self-discharge and shorten battery life.

Meanwhile, in the field of cable sheath research Bell metallurgists had discovered that calcium could be used instead of antimony to harden lead. And theory showed that calcium would not react destructively in a battery. The result is the new long-life calcium-lead battery which cuts battery replacement costs, goes for months without additional water, and needs but ⅓ the trickle current to keep its charge.

It demonstrates again how diverse lines of research come together at Bell Telephone Laboratories to keep down the cost of telephone service.

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The Nature of Engineering

By MORROUGH P. O'BRIEN

Dean, College of Engineering, University of California, Berkeley

There have been many attempts to define engineering and it is, perhaps, presumptuous to formulate another definition. However, the planning and accreditation of engineering curricula and the registration of engineers have developed an increasingly urgent demand for a generally accepted formulation of the nature of engineering and of the qualifications to be expected of engineers. The Committee on Engineering Schools of the Engineers Council for Professional Development has proposed, tentatively, a definition which almost meets the need but which, in my opinion, may be improved somewhat. My proposal is as follows:

The activity characteristic of professional engineering is the design of structures, machines, circuits, or processes, or of combinations of these elements into systems or plants and the analysis and prediction of their performance and costs under specified working conditions. Professional engineers are persons qualified to engage in this activity.

This statement impresses, many engineers as being unduly restrictive. It has been formulated in an effort to discern the sine quo non which characterizes engineering as a profession and to exclude the many other activities in which professional engineers engage successfully. Another approach, which is fallacious and misleading, is to develop the scope of engineering from an examination of the work of individuals who are evidently competent professional engineers. The boundaries of the profession thus described are vague and include many other occupations. The terminology employed in this statement requires explanation and its general intent should be clarified by examples.

Engineering Functions

The word "design" is employed here in the broad sense of planning but includes the more restricted meaning implied by such terms as machine design or bridge design. The general layout of a factory, mine, irrigation system, or power plant and the selection of suitable equipment are design just as much as the necessary calculations and drawings, and in fact, represent the higher levels of this function. Furthermore, one might expand the definition to include in the meaning of "design," the prediction of performance and cost, thus making the second half of the statement redundant; but in view of the more restricted sense in which "design" is so frequently used, this amplification seems desirable.

If design is the characteristic activity, what may be said about the other functions frequently listed as falling within the scope of engineering, such as research, teaching, production, construction, maintenance, sales, and others. The definition excludes them on the ground that they are not inherently characteristic even though many engineers engage in them successfully.

Consider, for example, the sales engineer who analyzes a customer's requirements, compares these requirements with the characteristics of his product, and makes a recommendation, supported by an analysis of costs. He performs an engineering function in the strict sense of the definition but it does not follow that all salesmen of technical products

should be classified as engineers.. Many professional engineers engage in research and teaching but it does not follow that anyone is to be classified as an engineer if the person engages either in teaching subjects basic to engineering practice or in research contributing to the solution of engineering problems. Planning a construction plant and the related flow of materials and predicting the construction costs is an engineering function but the direction of large scale construction operations does not ipso facto qualify a man as a professional engineer. It is because these, and other functions frequently mentioned as being within the scope of engineering, do offer opportunities for engineering practice in the strict sense of the term that professional engineers, in ever increasing numbers, engage in them.

Management is frequently mentioned as an engineering function because the design of the production methods and the design of the organization which is to carry out these methods is as important as the design of the machines. In this restricted sense, management would qualify as an engineering function under the definition proposed because the performance and costs of the individual machines, circuits, structures or processes, and of the overall productive system, including labor costs and labor productivity, would be involved in the design of an organization intended to carry on a technical activity. However, management is used in a broader sense and generally pertains to the direction of an organization. The design of an airline maintenance base, requiring an analysis of the components to be inspected and repaired and the cost of these operations, should be included, but the construction and the management of such a base are not inherently engineering activities.

The element of cost in the definition requires attention. In order to predict the initial or operating costs, the wages and productivity of labor must be known and this brings into the problem the results of many specialized activities such as cost accounting, time and motion study and so forth. To the extent that planning, analysis, and prediction are involved, industrial engineering qualifies as a branch of engineering within the definition, but cost accountants, motion study experts, and the many other specialists engaged do not thereby qualify as engineers.

Diversified Character of Engineering

Reviewing the many restrictions mentioned, the question may well arise as to whether anyone practices engineering. The answer is that engineering has become predominantly a group activity in which a single individual seldom carries through all the characteristic components at any stage of his career. Through education and experience one becomes qualified to "analyze and predict performance and cost" but only rarely does one individual carry through all the steps implied.

Engineering educations aim primarily at providing a basis for the quantitative and scientific aspects of the analysis and prediction of performance. A start is usually made in the direction of analyzing and predicting costs, but progress in college is not sufficient for professional practice. Experience is necessary to round out the individual's capacity for prediction of performance, especially of systems involving men as well as machines, and of costs. The best test of the qualifications to carry on engineering work in the sense defined is the actual doing of such work, usually in a sequence of assignments carrying increasing responsibilities for planning and prediction.

No mention is made in the definition proposed of such terms and phrases as "art and science," "use and convenience of man," or "the engineering method." This omission does not imply any lack of appreciation of the importance of professional ethics, services to mankind, or other aspects of professional practice. The aim has been to define that activity characterizing engineering and to strip

away everything else. Without this activity, there would be no engineering profession. Artesans are concerned with machines, circuits, structures and processes. Business men are concerned with costs and with management. Some physiologists and psychologists are concerned with the effect of machines on men. A certain aspect of these subjects, namely, design, analysis, and prediction, is characteristic of engineering. Only those individuals who are qualified to engage in this characteristic activity are engineers.

This discussion may be concerned with a fine distinction having no practical importance. Many words have been written on it without providing a clear cut basis for such practical matters as the registration of engineers, and perhaps a simple way of ending the discussion is to say that engineers are persons who are registered as such. Perhaps the distinction between engineering and what engineers do might be illustrated by reference to another profession, pharmacy. If one undertakes to describe pharmacy in terms of what pharmacists do, a visit to the corner drugstore would produce the conclusion that they are primarily managers or salesmen in small enterprises engaged in the sale of cigars, magazines, cosmetics, stationery, and so forth. One might add that they follow a special "pharmaceutical" method in the display of their wares, that they perform a public service, and that occasionally they fill medical prescriptions. This statement might be realistic, but it would not provide a basis for the registration of pharmacists or a guide to the best method for their education. The confusion regarding the nature of engineering stems from the same cause, namely, definition in terms of the work of men educated in engineering schools.

A definition should not set up a barrier to the acceptance of positions, nor should it set a limit on the programs of engineering schools. Engineers have been successful in many fields, and particularly in research, teaching, production, construction, sales and so forth, and there is no reason why engineering schools should not continue to consider these employment opportunities in planning curricula and advising students. However, these sidelines should be treated as such and should not become the principal objective.

Science and Engineering

There exists a difference in viewpoint and purpose between the engineer and the scientist which is basic and essential. The similarity in subject matter presented in their formal education has tended to obscure this fact, especially in the minds of many professors of both science and engineering, and it is of the greatest importance that this divergence be clearly understood. Chemists, geologists, mathematicians, and physicists differ from engineers not in the distance which they have traveled along the road of science. They have moved along a different road entirely, and one which bears only a superficial resemblance to that followed by the engineer. The road surface and other details of construction are sufficiently alike to confuse a stranger unfamiliar with the terrain but there the similarity ends. Failure to recognize that there are really two roads leading in different directions can only result in wasted effort and confusion. True, the two roads diverge gradually and there are cross-connections between them, but the fact remains that they lead to different destinations.

The activity characteristic of engineering has been defined. A similar treatment of the nature of science is difficult to formulate, especially for an engineer, but the differences between them pertinent to this discussion may be brought out by some quotations and examples.

In an address before the British Association for the Advancement of Science, R. V. Southwell[1] made the following statement:

[1] R. V. Southwell, F.R.S., Presidential address before Section G, 1938. Reported in *Engineering*, August 26, 1938.

"Wherein, then, does the outlook of the engineer differ from that of the physicist? Mainly, I think, in that his problems are inexorable, and he recognizes them as such. The physicist, despairing of progress along a path attempted, is free to try some other. The engineer has to solve the problem as it is presented, and some solution he must have, even though it be only approximate.

"Now uncertainty of this kind does not enter into the physicist's scheme of things at all. The physicist's problems are fundamental, and he is not the man to let them be complicated by additional difficulties. If corrosion is a potential source of trouble, then he will use gold if need be; if magnetic flux is calculable only for one or two particular shapes, then he will use those shapes. Because throughout he is free to choose; his shapes are not dictated by constructional or manufacturing requirements, nor his materials by considerations of strength or cost.

"Simple illustrations are best. Let us visualize the attitude to elasticity of a physicist who still retains some interest in Nineteenth-Century physics. He will be interested in Hooke's law, and in its interpretation as a statistical average of effects due to forces from very many atoms. He will recognize two distinct types of strain, the first involving change of dimensions without change of shape, the second change of shape without change of volume, and he will devise ingenious experiments for measuring the two relevant elastic moduli. In this connection he will study Saint-Venant's theory of torsion and of flexure, and he may even pursue the harder parts of elastic theory with the aim of eliminating errors in measurement that result from straining due to weight. But speak to him of the strength and distortion of an engine crankshaft—a matter of interest in practice, so long as engines tend to fail by torsional vibration; and if you find him interested then—well, he is an engineer in disguise! For speaking qua physicist he will say: "I see that both torsion and flexure are involved—that is, both of the two fundamental types of strain, but why study these in a body of such appalling shape?" And the engineer can only reply: "Because I must. This shape was not evolved for its intrinsic interest, but its strained form is important none the less —and very difficult to calculate."

One need not conjure up hypothetical examples to illustrate this difference in viewpoint. We have all experienced the complexity of engineering problems and the inadequacy of scientific principles and mathematical methods to their solution.

It is the purpose of science to seek out generalizations pertaining to natural phenomena, and this purpose would not be well served if considerations of utility entered into the choice of subjects for investigation. The progress of science has demonstrated that the most important advances have been made by men impelled only by curiosity and without thought of practical application. Science should hold firm to this viewpoint and should not be deflected by the glamour or the availability of funds on the side of practical applications.

My comments thus far have been directed towards what is sometimes termed "pure science," the word "pure" connoting, apparently, freedom from the taint of utility. We should now give consideration to the engineering sciences, such as dynamics, elasticity, fluid mechanics, heat transfer, mass transfer, metallurgy, combustion, and others. In substance, the subject matter of these fields may be classified somewhere under chemistry, mathematics, or physics: but they have lost in large measure their appeal to the pure science departments of the universities and colleges. Some individual scientists, principally in the smaller science departments, carry on work in these subjects, but the attitude generally seems to be that they are no longer fruitful fields for scientific endeavor, or at least that they are not worthy of the efforts of first-class scientists.

The scientist idealizes and simplifies his problem by assuming in his theory, and realizing as far as possible in his experiments, simple geometry, frictionless fluids, reversible reactions, masses concentrated at a point, isotropic materials, and so forth. This approach has been fruitful in yielding the many generalizations of science but the effort stopped short of providing analytical tools for the solution of engineering problems.

A classical example is the huge gap

between theoretical hydrodynamacis and practical hydraulics which existed until very recent years. During the eighteenth and nineteenth centuries, mathematicians and physicists developed theoretical hydrodynamics almost to its present state, but the results predicted by this theory were so completely at variance with experience that the hydraulic engineer developed his design procedures on a purely empirical basis. The theoretical results were correct for the conditions assumed but these conditions were not encountered in engineering practice.

Aeronautical engineering, with its requirement of low resistance and weight, provided the stimulus for the investigations, both theoretical and experimental, which have extended classical hydrodynamics so as to contribute to the solution of engineering problems. It should be noted that it was the spur of a deficiency of design data and methods which led to the rapid expansion of the engineering science of aerodynamics and not the exploratory urge of the pure scientist.

Evolution of Engineering

Engineering developed first as an art, dependent chiefly on judgment and experience, and developed the scientific side later not because engineers were incapable of understanding science but because scientific principles proved almost useless in solving engineering problems. Progress was made in small steps, using the experience gained on one successful development to forecast the behavior of another slightly larger or different. The money involved made drastic innovation dangerous. Failures were carefully studied to indicate their causes. This empirical attitude led to the development of methods of model-testing as a means of gaining useful generalizations, and as insurance against the failure of particular designs. The model scaling laws, required for the transference of experimental data to a prototype of different size or one operated under different conditions, brought into consideration many of the generalizations previously established in pure science. Success in this limited application of scientific principles led to further efforts in the same direction.

The basic problem was, of course, that in the usual engineering problem many variables operated simultaneously, and even the boundary conditions were too complex for analytical treatment. At present, the gap between basic science and engineering design is being closed in many of the engineering sciences by working forward from pure science and backward from the tests of working units, but there remains much to be done in all of them. The requirements of engineering design have provided the stimulus and and the support for these important studies which are an essential link in the process of applying the results obtained by the basic sciences.

Science, either pure or applied, is not likely to result directly in profitable developments and industry cannot justify substantial participation in it. In spite of the implications of some publicity, only a few large companies engage in research at their own expense, and such as they do is usually directly related to a development problem. Some government laboratories, such as the Bureau of Standards, do engage in research in both the pure and engineering sciences, but their principal efforts are directed at development work, frequently for military purposes. The principal burden for research in science falls upon the educational institutions; and, as regards the engineering sciences, the responsibility is, in my opinion, clearly that of the engineering schools. It is only in recent years that this responsibility is being realized, and far too few engineering schools have taken steps to meet it. The post-war upsurge of foundations sponsored by engineering schools has been directed too much at development work and too little at the extension of the engineering sciences. The deficiency in these areas is great and it is to be hoped that the newly established National Science Foundation will provide the stimulus and some of the support for a more intensive effort.

The individuals working in the engineering sciences have essentially the same viewpoint and follow the same methods as their colleagues in the pure sciences. Many of them received their undergraduate and graduate training in the pure sciences, while others came up through the engineering curricula and later found that their interests lay in science rather than engineering practice. The difference between these scientists and the pure scientist lies in the fact that the general area of investigation is selected with a view to engineering applications and their environment is one likely to maintain this interest.

Historically, the stimulus for the development of the engineering sciences has come from the needs of engineering practice, and there is some danger that groups working in these fields will lose their drive by becoming isolated from practice. An engineering school should include in its faculty men whose interests range from science to engineering practice; and when this situation is achieved, there will be a two-way transmission of ideas and methods, practice stimulating the engineering sciences with its problems and these sciences supporting practice with their results.

The Function of the Engineer in Society

In "America's Needs and Resources" [2] the productivity of labor and it relationship both to machine power and to real income is summarized as follows:

Sources of Power in Industry

Year	Men	Animals	Mach.	Goods (1940) per Hr.
1850	15%	79%	6%	$0.27
1900	10	52	38	.56
1930	4	12	84	.82
1960 (interpolated)	3	1	96	1.61

[2] Twentieth Century Fund. Macmillan, New York, 1949.

The goods per hour are corrected to 1940 prices and are a measure of the return for one hour of productive effort. In the period 1850 to 1940, the average industrial working week was reduced from 72 to 43 hours.

Through the design of machines, circuits, structures, and processes, engineers provide the means by which the productivity of labor is increased and the general standard of living raised. Many other groups participate in this process and there is no implication intended as to the relative importance of engineers and others in this respect. However, it is true that the efforts of engineers, using engineer in the sense of the definition, are directed almost solely towards increasing productivity or reducing the cost of essential goods and services and, thus, towards making possible a higher standard of living.

Engineers should understand this function which they perform in society and should be aware of, and as a group work to influence, the policies and laws which tend to expand or circumscribe his activities. Engineering works, and the beneficial effects which they produce, require capital expenditures and a steady flow of capital, public and private, is essential to continued engineering activity. Tax laws, depreciation policies, real wages, interest rates, and many other factors influence the availability of capital for these purposes. As an example of the type of major problem, in which engineers may play a part, either individually or as a group, is the present paradoxical situation of rising unemployment in a period of prosperity. Labor productivity has been rising rapidly since the war and the volume of goods and sciences required by a growing population is being supplied by an almost constant working force. Unemployment is growing because the increase in employables is not being absorbed. You may well ask what can engineers do about such a problem. I will not discuss the question in detail, but I will give two examples. In California, the ceramics industry is small but grow-

ing, and it appeared that some assistance through research and development might yield substantial results. To provide a background for this program, a study was made of the invested capital per job in this industry and it was found that the ceramics industry required approximately $3,000 per job as compared with $30,000 per job in certain branches of the chemical industry and $8,000 per job in industry as a whole. This result showed that, to the extent that additional production of ceramic materials is needed, investment there would produce more jobs than in almost any other technical industry.

Another example, and one on a national scale, is the work of the Water Policy Panel of the Engineers Joint Council which is studying the desirable policies and criteria of the Federal government regarding water projects, irrigation, flood control, navigation, power, drainage, water supply, and so forth. The objective is to develop criteria for the appraisal of the benefits of these projects and for the allocation of costs. For engineers generally, the importance of this work lies in the fact that money spent on such projects must ultimately be derived from taxes on individuals and corporations. If not collected in taxes and so spent, it would become potentially available for investment in other productive facilities. The decision as to extent to which the Federal government should participate in these water projects should depend upon the extent of the benefits derived, and it is primarily the engineer who is responsible for appraising these benefits. If this appraisal is realistic and complete, it will provide a basis for comparing their effect on productivity and on the general welfare with other potential investments. Each water project is using capital which might be used to build chemical plants, steel mills, highways, and other works. The engineering profession is in a position to aid materially in this matter by providing both reliable and uniform methods of appraisal and facts regarding the effect of alternative investments.

Engineering Education

The practice of engineering involves as much of art as of science, and the art of engineering is best acquired through experience. Consequently, the young engineer should come to grips with practical problems at as early an age as possible without, however, sacrificing essential education. This situation has resulted in the general acceptance of a basic four-year program as the usual education of an engineer. Some schools have shifted the beginnings of practical experience down to the early years of the curriculum by means of the co-operative program, and this appears to be an effective arrangement. Those graduates who practice engineering, within the meaning of the definition given in this paper, probably should spend one or more years in graduate study preparatory to professional practice; but with or without graduate study, continued study will be necessary for them.

It is not my intention to discuss curricula as such, but only to make a few general observations on matters which I feel, have not been sufficiently stressed in many discussions of engineering education.

Engineers are concerned with the expenditure of capital for equipment and plants. Their employees, whether public or private, authorize the expenditures in the expectation of realizing both the predicted performance and the predicted operating costs. Excessive costs or deficiencies in performance have resulted from plans based on theoretical analyses, from undue interpolation of past experience, from unpredicted difficulties with foundations and materials, and many other causes. The obvious result is a very conservative attitude on the part of the professional engineer towards innovation and change. Defects frequently do not appear for years and a cautious, waiting attitude is adopted towards new developments. All this is fitting and proper because of the responsibility of the engineer for the investment of capital.

As regards engineering education, the

problem is to instill in the minds of the student a deference for experience and good practice without at the same time closing his mind to innovation and change. It is a dilemma of major importance, and I have no solution to offer except the suggestion that engineering courses keep to a minimum the attention to established design procedures, which the graduate will easily acquire on the job if his general background is good. However, it is also important that the engineering schools continue to emphasize the importance of experience and sound judgment.

Another aspect of the practice of engineering which has a bearing on engineering education is that it has become a group activity. Extreme individualists may find their niche in engineering but, in general, the engineer must fit into a team. The usual engineering curriculum, with its group work in laboratories, serves both to test and to develop this attitude, but the general pressure of the engineering curriculum leaves too little time for campus activities and social affairs, which will do more than any possible selection of courses to develop the understanding of men necessary for group endeavor.

A third aspect of the practice of engineering, which has a bearing on engineering education is the attitude of the engineer towards the job to be done. The scientist is free to work on the problem which interests him and, if he loses interest, he can choose another. The engineer must work on the job assigned and the sooner he acquires the viewpoint that the most interesting and important job is the one which *must* be done, the happier and more fruitful will be his professional life. This motivation and stimulus of the need for a solution of a problem posed by others is most important and the beginnings of it should be developed in the engineering school. These remarks are not intended to imply that an engineering student should not explore fully his interests and aptitudes or that practicing engineers must become automatons; rather the engineer, after finding the niche which suits him best, should attack each problem assigned with all the zest and enthusiasm that he would if he chose the problem himself and I think the engineering program of study helps to develop this viewpoint through the emphasis on laboratory experiments and problems.

The essence of these comments is that engineering education presents two paradoxical requirements, namely, (1) that individuality and imagination must be preserved in students who must also be prepared for group activity, and (2) that open-mindedness towards innovation must be developed along with respect for value of experience and precedent. These problems are, I think, common to all types of professional education. They are acute in engineering education because engineering has generally retained, for good reason, the four-year period of basic training.

Process Engineering

In his address at the Chemical Engineering Congress at London in 1936,[3] George Granger Brown stated:

> "Although the term mechanical engineer and electrical engineer may be interpreted as indicating the type of energy with which the engineer deals, so much of chemical engineering is physical as well as chemical that it often appears that the expression "Process Engineering" might be a more pertinent designation for what we now know as chemical engineering. Analysis of the types of operations conducted by so-called chemical engineers indicates that those operations most commonly encountered are mainly physical in nature."

This term, if it had been generally applied, would have obviated many of the difficulties which have attended the development of chemical engineering as a branch of engineering profession. I shall use the term process engineering in this discussion.

The process engineer designs or selects the machines, equipment, and materials and arranges them in a system in order

[3] Trans. Chem. Eng. Congress of World Power Conference, Vol. IV, p. 122, Percy Lund, Humphries & Co., London, 1937.

to control the environment of a chemical or physical process so as to achieve the predicted output at minimum cost.

Process engineering came to separate professional status after civil, electrical, and mechanical, and it missed that early phase of the development of the other branches of the profession in which art, or judgment based on intuition and experience, was the predominant influence. By the time process engineering was recognized as a separate branch of engineering through the establishment of curricula for the education of process engineers, the number of physical and chemical processes falling within the cognizance of process engineers was so great that a knowledge of the art of each was clearly impossible. Science and engineering science had progressed to a point such that the field could be broken down into unit operations and unit processes and the educational program was thus simplified. You are more familiar with this historical development than I am and I summarize it briefly only as a prelude to my comments on the relationship between process engineering and the other curricula.

Frequently, when I am asked to explain my conception either of the nature of engineering or of the desirable end point of an engineering curriculum, I turn to the annual prize problems of the American Institute of Chemical Engineers as the most compact and clear-cut example representative of my views. These problems vary in character and scope from year to year. In general they exemplify the nature of engineering as here defined in that they apply science and engineering science to the prediction of performance and cost and, from the standpoint of the educational process, they synthesize the preceding courses of instruction in an effective manner.

One point at which I am at odds with the typical curricula in this field is that the major unit processes of heat transfer, fluid flow, and, mass transfer are not treated in a sufficiently fundamental manner and too much of the instruction is given by instructors who are not specialists in these subjects. Historically, the reason for this situation is that the older departments would not generalize the treatment of these subjects so as to provide an adequate background for the process engineer, but this situation is changing and a different pattern is now possible in many institutions. I am particularly interested in this point because many of the engineering science courses necessary for the process engineer should also be available to the students in other curricula such as mechanical engineering, ceramics, and extractive metallurgy. This is a detail of curriculum planning which will have varying importance in different institutions.

A major point which I wish to emphasize particularly to this group is that the usual curriculum in chemical or process engineering comes nearer, in my opinion, to what all engineering curricula should be than any other. Some, such as electrical engineering, emphasize science and analysis to the almost complete exclusion of the cost factors and of the synthesis of science and economics into a design problem. Others, such as industrial or administrative engineering in some institutions, have reduced the science content to such an extent that it is questionable whether the graduates can undertake professional engineering in the sense defined here. The process engineering program in most institutions has struck a happy medium which should set a pattern for the modification and improvement of the other curricula.

An Extension of Graduate Education in Engineering

By L. E. GRINTER

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Research Professor of Civil Engineering and Mechanics, Illinois Institute of Technology

An interesting development in graduate education in the South is being stimulated by the Board of Control for Southern Regional Education. This Board, acting under the Chairmanship of the Honorable Millard F. Caldwell, Former Governor of Florida with Dr. John E. Ivey, Jr. as Director, is undertaking to assist the Colleges and Universities of thirteen Southern States to integrate their educational activities. The Board of Control for Southern Regional Education was formally organized in 1949 under an interstate compact which has now been fully approved by the legislatures of twelve of the participating states.[1] The Board's stated purpose is to assist "states and institutions and agencies concerned with higher education in their efforts to advance knowledge and to improve the social and economic level of the Southern region." It concentrates, under mandate of the compact, on graduate, professional, and technical education. The wisdom of the objective is very clear since it is obviously impossible for every Southern State to provide education at a high level in every field of professional and scientific specialization. Although a start has been made in only a few fields it is visualized that eventually the regional group of Southern States will be supporting at least one program of the highest quality in each field of specialization extending through the doctorate level. When this is achieved in the several fields of engineering, it will no longer be necessary for southern students to leave the South for advanced graduate work in engineering. In fact, it is reasonable to assume that more students from other sections of the country might well be attracted by the idea of taking graduate work in engineering in the South.

The Board of Control recognizes that financial restrictions upon the extension of facilities for graduate research as well as staff limitations are likely for some time in the future to restrict graduate study in such fields as engineering below the level of the doctorate in many southern states. Hence, an investigation of supplementary facilities that have as yet been little used for educational purposes was decided upon. The first of these explorations was undertaken with regard to the Tennessee Valley Authority, the principal focus being on development and demonstration of *methods* for more effective cooperation among institutions of higher learning and non-school agencies. TVA was selected as a starting point both because of the interest shown by that agency and because of the wide variety of its professional competences and program activities which might have applications for graduate study and research. A committee of educators was appointed by the Board of Control for Southern Regional Education to meet at Knoxville and with the cooperation of the officers of TVA

[1] The thirteenth State—Virginia—also has approved the compact subject to a constitutional amendment; the necessary amendment was introduced at the last session of the Virginia General Assembly. Texas also has participated in activities of the Board; it is expected that a resolution to approve the compact will be introduced at the next session of the Texas legislature.

to inspect TVA research facilities and other program activities in all fields of academic interest. The inspection was carried out during the week of May 15–20, 1950 by the following committee of ten members:

J. Hillis Miller, President of the University of Florida, Chairman
A. J. Brumbaugh, Vice President, American Council on Education
L. E. Grinter, Research Professor of Civil Engineering, Illinois Institute of Technology and Mechanics.
Fred J. Kelly, Specialist for Land-Grant Colleges and Universities, U. S. Office of Education
F. D. Patterson, President, Tuskegee Institute
W. W. Pierson, Dean Graduate School, University of North Carolina
Russell S. Poor, Chairman, University Relations Division, Oak Ridge Institute of Nuclear Studies
Floyd W. Reeves, Professor of Administration, University of Chicago, and former Director of Personnel, TVA
Fred C. Smith, Vice President, University of Tennessee
Frank J. Welch, Dean, College of Agriculture, Mississippi State College

Many TVA officials gave a great deal of time to this project, in particular, George F. Gant, General Manager, and Harry L. Case, Director of Personnel. Staff of the Board of Control worked closely with the Committee in its explorations.

Inspection of TVA

The work of inspection was subdivided by the appointment of three sub-committees. Since each sub-committee produced a rather full report, the present report will be limited in its detailed aspects to the work of Group 1 which conducted the inspection of facilities for research in engineering. This group, acting under the Chairmanship of Dr. Russell Poor of the Institute for Nuclear Studies at Oak Ridge, also was served by Dr. A. J. Brumbaugh of the American Council on Education and the writer. This sub-committee concerned itself with the following TVA divisions: Water Control Planning, Design and Construction; Chemistry and Chemical Engineering; Power Utilization; Power Operations; and Power Engineering and Construction. It is clear that the following academic fields were encompassed: Civil Engineering, Hydraulic Engineering, Electrical Engineering, Chemistry, Chemical Engineering and Agricultural Engineering. On successive days the committee visited Norris Dam and the Hydraulic Laboratory, Wilson Dam and the Divisions of Chemistry and Chemical Engineering, and the Power Division at Chattanooga.

The general plan of inspection which was adopted and which on the whole proved quite satisfactory was as follows:

Conferences were held with the Division heads and with supervisors in the several Divisions for the purpose of (a) securing information as to unique opportunities for research by graduate students either at the master's or doctor's degree level; (b) discovering opportunities that might be open to university faculty members for participation in TVA activities to the mutual benefit of the universities and TVA; (c) identifying personnel in TVA that would be competent, available and willing to supervise wholly or in part dissertations or other research projects of graduate students; (d) finding what educational experiences not strictly research in nature might be available in TVA; (e) determining what financial and administrative problems would be encountered and how these might be met; (f) sensing the general attitude of key administrators toward any cooperative undertaking of the kind under consideration.

Opportunities for Cooperative Research

In very brief summary, the sub-committee saw possibilities for cooperative arrangements between TVA and educational institutions in the following fields of engineering:

(1) Water Control of the River Channel including Hydrology, Hydraulics and Dam Design

Obviously there is a wealth of experience in dam design within TVA. Although of a very practical nature, contact with this engineering office would be a valuable experience for a graduate student, and an opportunity also exists to study accumulated experimental data. The laboratory of hydraulics at Norris is one of the best equipped laboratories in the country. Experimental work comparable to doctorate research is continually under way. A cooperative spirit that would be of great help in starting doctorate research was evident in this laboratory. In hydrology the accumulated data of TVA would furnish excellent material for thesis study.

(2) Chemistry and Chemical Engineering and Fertilizer Research

The TVA chemical laboratories have had an extended program in the study of phosphates in continuous operation. A graduate student would be fitted into this program at any level without great difficulty. The opportunities of combining experience in chemical research with observation of pilot plant investigations in chemical engineering appeared very promising to the committee. A new laboratory building soon to be in operation will further strengthen this section of TVA's activities. The opportunities strictly in chemical engineering appeared excellent at the master's level.

(3) Power Engineering and Power Utilization

TVA has all of the problems experienced by any other electric utility, and the study of these problems leads to possibilities for cooperative research and thesis investigations. In power utilization the main emphasis in research seems to revolve around economics. A great body of economic data have been accumulated over 15 years which could be studied by the methods of statistics, factor analysis and probability. In some of the work a high degree of mathematical competence would be necessary for research at the level of the doctorate.

Administrative Problems

Although the inspection committee found excellent opportunities for cooperative thesis investigations both at the master's and the doctor's level, and although the administrations of TVA and of the Universities appear to desire cooperation, the usual difficulties were encountered in attempting to develop a plan for a working cooperation. The overriding considerations appear as follows:

TVA has clearly defined responsibilities with respect to certain physical developments. These developments of flood control, navigation and power are of great interest to engineering education. Contact with these developments would challenge the imagination of graduate students.

TVA has a policy of cooperative association with surrounding institutions. For example, it does not distribute fertilizer to farmers. Rather it has entered into arrangements for distribution with the land-grant colleges and universities and with farmers cooperatives. It has distributed 22,000,000 seedlings a year, helped develop 33 state, county and municipal parks, but always by working through other institutions and organizations. Hence, TVA has established precedents for cooperative arrangements looking toward regional development.

TVA has pursued the problem of research on the same cooperative basis. In many cases, it has entered into cooperative arrangements with appropriate agencies or into contractual arrangements of a more formal nature. It also has internship arrangements with colleges and universities not only for the purpose of assuring itself a supply of competent personnel, but also to encourage the extension of professional and graduate training in the institutions of the region.

Hence, a basis for cooperation truly exists since, in the words of the General Manager of TVA, "It is of great concern to TVA that its activities and its method of administration be such as to fit into and be a part of the Region." And further, "If additional and improved

methods of relationship with the institutions of higher education can be developed, from a selfish point of view I think these relationships will be of great stimulation to the TVA staff."

The Student and the Professor

There was much informal discussion of the difficulties inherent in the conduct of a thesis investigation at a great distance from a university campus. It was recognized that, despite the excellence of the TVA staff in many fields, academic direction of certain phases of the thesis research would be necessary. Hence, it seemed agreed that techniques would have to be worked out to interest the professor as well as the student in the possibility of conduct of research within TVA. Such devices as employment of the professor on a consulting basis, the provision of traveling expenses to make it possible for the professor to visit the TVA research laboratory, for the student to make several trips between the two institutions and for the associate thesis director in TVA to visit the campus, were considered to be partial answers to the difficulties discussed. A complete answer to all obstacles lies only in making the cooperative research arrangement desirable not only to the administrative officers of the University and of TVA, but to the professor, the student and the associate thesis director in TVA. If the cooperative arrangement is without value to or is unfavorable to any one of these five parties, cooperation will be spasmodic or nonexistent.

Proposed Administrative Arrangements for Collaboration between Southern Colleges and Universities and "Non-School" Agencies

In presenting an administrative structure to implement programs of graduate education inherent within various non-school agencies in the Southern region—as are partially set forth in Section I above for the Tennessee Valley Authority—the Committee believed that any effective arrangement of university and agency collaboration must be anchored to a few general principles of administration of these relationships. Among the most significant of these principles are the following:

(1) That of institutional * responsibility for award of academic degrees. Included in this principle is acceptance that the institution would approve standards of instruction and programs of study and research. The institution would be responsible for the evaluation of student accomplishments, including the research entering into a dissertation from the point of view of acceptability for satisfying institutional requirements.

(2) That of liberal recognition and acceptance of extra-mural credits obtained under programs approved by institutions and non-school agencies through work in the agency.*

(3) That of institutional approval of agency staff as eligible to guide and direct research. This principle carries with it the policy of recognizing agency staff members as eligible to direct thesis research and the desirability of participation of appropriate agency staff in final examinations of students whose research they have guided.

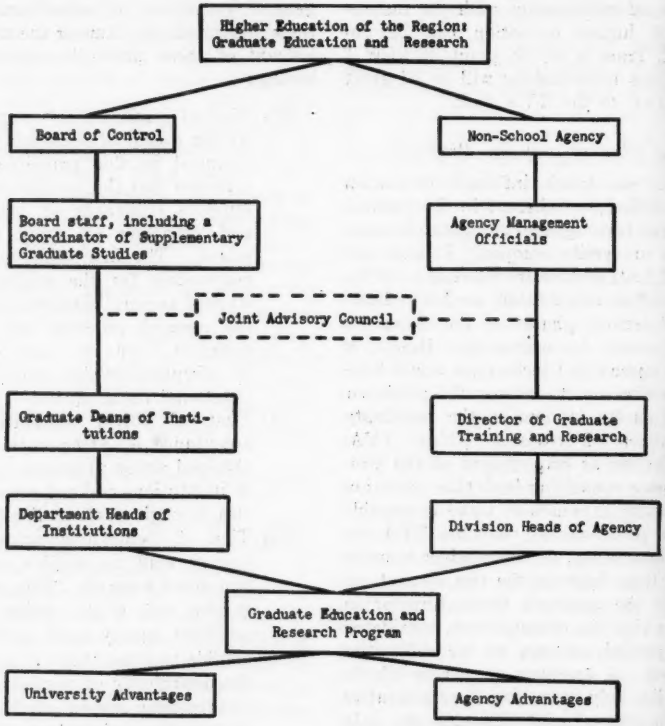
(4) That of agency approval of institutional staff and of graduate students for work within the agency.

(5) That of mutual agreement between educational institutions and non-school agencies on policy regarding the publication of research findings.

(6) That of providing means for the exchange of information to both institutions and to non-school agencies of research in progress and of other educational opportunities in which both might be concerned.

(7) That of making opportunity for graduate study and research avail-

* The "institution" refers to the university; the "agency" refers to TVA or any other cooperating non-school organization.


Higher Education of the Region: Graduate Education and Research
Board of Control
Non-School Agency
Board staff, including a Coordinator of Supplementary Graduate Studies
Agency Management Officials
Joint Advisory Council
Graduate Deans of Institutions
Director of Graduate Training and Research
Department Heads of Institutions
Division Heads of Agency
Graduate Education and Research Program
University Advantages
Agency Advantages

1. Faculty stimulation
2. Availability of new facilities
3. Expanded graduate offerings
4. Expanded research opportunities
5. Merging of theory and practice
6. Develops regional understanding

1. Staff stimulation
2. Improved research
3. Use of university facilities
4. Aid from university faculties
5. Help in staff recruitment
6. Expands regional service

able to all groups in the region without regard to race.

The committee regarding the administrative structure represented by the following organizational chart as adequate and workable.

The many and varied details involved in the administration of the programs contemplated in the foregoing sections should be formulated gradually as needed by those officers in the indicated positions of responsibility.

Conclusion

The writer believes that the Board of Control for Southern Regional Education has indicated a direction for greater cooperation between universities throughout the country and government laboratories, regional industrial-research organizations, and industrial laboratories. Such research organizations need to learn more of their responsibilities for the production of scientific personnel. And once the Uni-

versity has drawn the cooperation of such non-school agencies it must relax sufficiently to make it possible for the advantages of joint training of graduate students to become a practical possibility. It is the writer's understanding that such cooperation is not as unusual in Europe as in America.

In final reference to TVA it is, of course, self-evident that TVA is a national institution, and, as such, any arrangement provided for students from southern states would be open to students from other sections of the country. It is also evident that TVA is only one of a long list of non-school agencies in which research is either the primary objective or at least a very important objective.

College Notes

Two new buildings were put into use on the campus of **Missouri School of Mines and Metallurgy** of the **University of Missouri** at Rolla, Missouri, with the opening of the fall semester on September 11. One is the new Mechanical Engineering Building just completed at a cost of $500,000.00, and which will house the Mechanical Engineering Laboratories. The other is the new dormitory, erected at a cost of $600,000.00.

Paul Harteck, head of the University of Hamburg and one of Germany's foremost authorities on hydrogen isotopes, is to join the staff of **Rensselaer Polytechnic Institue** on January 1 as visiting research professor of physical chemistry. Dr. Harteck's most recent work has been in isolating quantities of tritium, the probable central material in the projected hydrogen bomb.

Guido Ferrara, assistant professor of electrical engineering at the **University of Detroit**, has been named acting Director of the Department of Electrical Engineering.

Pietro Belluschi of Portland, Oregon, who has gained recognition as one of this country's foremost architects, has been appointed dean of the School of Architecture and Planning at the **Massachusetts Institute of Technology.** The Institute's new dean will succeed William Wurster, who held the position from 1944 until May, 1950, when he returned to California to assume the post of dean of the School of Architecture of the **University of California.**

A distinctive "engineering project plan" which places a premium on student ingenuity and initiative has been placed in operation on a college-wide basis in the College of Engineering at **Cornell University.** The program requires each student to complete an individual problem of specific research as part of his final year's work in the five-year undergraduate curriculum. Projects are assigned to single students or to teams of two or more. Although instructors are available for consultation, it is left to the students to use their scientific imagination and technical ingenuity in finding a solution, Dean Hollister explained. A primary purpose of the work is to provide the young engineer with experience in research procedures in preparation for development problems which commonly arise in professional work after graduation.

The Social Impact of Technological Change

By YALE BROZEN

Professor of Economics, Northwestern University

The first Industrial Revolution—during which men learned to use metals and harness animals and in which they invented the plough, the wheeled cart, and the sailing ship—preceded 3000 B.C. Although it produced Babylonian, Egyptian, and Greek civilization, its benefits were confined to a few people in each of those states. Most of the increased product made possible by technological advance was funneled to the support of a ruling class. This class contributed much to the technique of administration, to literature, art, astronomy, mathematics, and philosophy, but it contributed little to the further advance of technology, since its members had no regular contact with the effort of production. The class divisions which resulted from the first Industrial Revolution ended the Revolution.

The second Industrial Revolution began its most explosive phase after 1660 in Western Europe. It terminated about 1918. (After that date, the rate of growth of technology began to decline, according to Lewis Mumford and S. Lilley.) Its benefits, in contrast to the first Industrial Revolution, have spread to almost all the inhabitants of its primary locale, Europe and North America.

Political Consequences of Change

The benefits of technological advance included not only rising material standards and improving health and longevity, but also the increase in human dignity resulting from the displacement of human muscle by inanimate sources of energy. The decline in slavery and the rise of mass democracy were a part of the same movement.

At present, the political consequences of the shifting balance of power resulting from developments in the area of military weapons—particularly the atom and hydrogen bombs—occupy newspaper headlines and the minds of men. Somewhat less obvious is the fact that technological advance in the production of subsistence goods may do as much to shift the balance of power as advances in the powers of destruction. Through a reduction in that portion of a nation's resources which must be devoted to the maintenance of living standards, resources can be released for the development, production, and use of weapons. If Chinese, Indian, or Russian productivity could be raised to a level comparable with that of the United States while living standards remained unchanged, the release of resources for war effort would make them far more formidable enemies than would the mere possession of the knowledge necessary for building an hydrogen bomb.

In the past, we have seen the center of world power shift from Spain to Great Britain and then to the United States because of more rapid technological advance in the rising nations. Whether world power will shift to Russia or to India or China is a question now troubling those who must make decisions on political and military alignments.

More than technical knowledge is required for economic progress and growth in military potential. Knowledge of technological possibilities can be fruitfully applied only by the investment of large amounts of capital. Even if no equipment were required to make use of better techniques, capital would have to be in-

vested in research and education. Acquiring and spreading the "know-how" necessary for improvement in productivity requires the diversion of men from current production and, therefore, requires capital for their support. The cost of sending British industry teams to study methods in the U. S., which was partly financed by ECA, is an example of the capital required for the task of spreading knowledge.

Thus the backwardness of a region may result from a lack of capital rather than from a lack of technical "know-how." England does not lack the knowledge of technological possibilities or even the technological leadership required for improvement of her average technology. Her great problem is her lack of capital. Her social mores, industrial and economic organization, and tax structure have caused a dearth of this factor. As a consequence, the English government faces the problem of increasing the capital supply in order to raise the technological level. More capital and improved technology will be obtained only if English standards of living are reduced, unless capital can be obtained abroad.

Because of the intimate connection of capital supply with technology, there has been a tendency to confuse the lack of capital in backward areas with the technological ignorance of those areas. Point IV is aimed toward the export of "know-how" to such areas as a method of improving their productivity. But until the economic, social, and governmental structures of those areas are changed to promote the growth and productive use of capital, their technologies will continue to lag.

The United States today, as well as backward areas, is confronted with this problem. Our technological advance is directly hinged to the capital supply no less than that of the rest of the world. If we follow policies which reduce the rate of saving or inhibit its flow into capital markets, enterprises will be unable to obtain a large supply of this resource. The resulting reduction in the supply of capital will carry down with it the rate of technological advance. The international implications of this reduction in a world in which we are engaged in a race for power are obvious.

Technological development has depended not only on the supply of capital,

TABLE 1*

WORLD PRODUCTION OF MECHANICAL ENERGY, 1935.

Expressed as Thousands of Tons of Bituminous Coal

	Total Power		Total Power
The world	1,649,266	Germany	207,085
North America	659,619	Italy	11,126
South America	45,834	Poland	29,515
Europe (exc. of U.S.S.R.)	632,112	Rumania	14,113
U.S.S.R.	141,568	Spain	9,658
Asia (exc. of U.S.S.R.)	127,246	Yugoslavia	2,461
Africa	15,123		
Oceania	26,764	China	26,755
Selected countries:		India	25,136
United States	621,696	Japan (proper)	48,863
British Isles	226,655	Australia	11,908
Czechoslovakia	17,247	Union of South Africa	13,587
France	54,430	Manchukuo	11,828

* A. P. Usher, "The Steam and Steel Complex and International Relations," *Technology and International Relations* (ed. by W. F. Ogburn, Chicago, 1949), p. 66.

TABLE 2†

WORLD RESOURCES OF MECHANICAL ENERGY

Expressed as Millions of Tons of Bituminous Coal

	Total		Total
The world	8,670,285.8	Germany	308,170.5
North America	3,087,143.6	Italy	11,320.4
South America	166,881.0	Poland	97,380.5
Europe (exc. of U.S.S.R.)	789,548.8	Rumania	6,142.5
U.S.S.R.	1,313,685.3	Spain	17,220.0
Asia (exc. of U.S.S.R.)	2,347,544.1	Yugoslavia	11,359.0
Africa	765,005.3		
Oceania	190,477.7	China	2,158,840.0
Selected countries:		India	99,754.6
United States	2,513,693.4	Japan (proper)	41,658.2
British Isles	177,047.5	Australia	141,158.0
Czechoslovakia	32,932.1	Union of South Africa	210,370.0
France	33,472.0	Manchukuo	4,804.0

† *Ibid.*, p. 69.

but also on energy resources. The displacement of human muscle as a source of energy was possible because of the availability of wind and water power, before the steam engine, and the availability of fuel since. An index of advance can be drawn almost as readily from data on the amount of energy used as from data on the quantity of capital or from direct measurement.

Using the data of 1935, the four largest users of mechanical energy were the United States, the British Isles, Germany, and the U.S.S.R. in that order. The fall of France early in World War II might have been predicted from the fact that its energy use, and, therefore, its national power, was only about one-fourth that of Germany.

If technological advance continues to depend on energy resources, aside from capital requirements, then relative potentials for different nations may be measured in terms of their coal, oil, and water-power reserves. Those of North America are more than double those of the U.S.S.R., but they are little more than those of Asia exclusive of the U.S.S.R. Europe (exclusive of the U.S.S.R.) and Africa each have potential energy resources equal to about one-fourth those of North America.

In terms of the present direction of evolution of technology, Asia (particularly China, which has over nine-tenths of Asia's energy reserves) and North America have the greatest potentialities for progress as far as energy resources are concerned. In terms of potential population growth, Asia is more likely to become the dominant world power than either the U.S.S.R. or North America. Only if we succeed in maintaining a rate of capital growth sufficient to offset the energy and population potentials of Asia can we maintain our dominant position in world affairs.

Russia's great emphasis on atomic energy development is the logical result of the deficiency of her energy reserves relative to those of North America. If atomic and solar energy become economic sources of power, the world's energy and political balance may be changed.

Technology and Population

Technology has produced changes in the pattern of individual lives through its impact on the goods available for consumption, on the size of the family and its function and outlook, on the occupations

followed by men, and on the security of states. In addition, it has produced vast changes in population. The 1600 million increase in world population in the last 250 years is nearly three times as great as the 600 million increase of the preceding 10,000 years, a period 40 times as long. The annual rate of increase rose from 0.64 persons per 1000 to 5.5 per 1000.

Populations not accustomed to living with modern technology typically have high birth and high death rates. If, in addition, population density is high, the introduction of advanced technology in backward areas simply contributes to further increase in population density with little effect on living standards. Only where initial population densities are low (if birth and death rates are high), or where population increase is exported, does the introduction of modern technology lift standards.

Social change lags behind economic development. Where population densities are low, a rise in income resulting from technological advance can be maintained as a rise in per capita income for fairly long periods despite high birth rates and declining death rates. If maintained long enough (about a century) changes in attitudes determining marriage age and family size can take hold before population rise sends per capita income back to low levels. Technological advance, in that case, produces a permanent increase in standards.

Unfortunately, many of the backward areas in the world today have high population densities and potentialities for explosive population increase. Egypt, India, China, Korea, Formosa, and the Caribbean islands find improved productivity a source only of more mouths to feed. Increased production brings the usual drop in death rate and rise in population. Fertility, however, does not drop enough to make permanent the movement away from the Malthusian limit.

One of the reasons for the drop in birth rate with technological advance, when this occurs, is the urbanization of population which seems to be inevitably associated with advance. As productivity on farms rises, it becomes possible for an increasing proportion of the population to live in cities. Not only does it become possible, but the movement occurs. The directions of technological advance have been such that the assembly of materials dictated by technical requirements and the cost pattern dictated by the available forms of transport make economic the location of major portions of production at certain restricted sites. The resulting urbanization of the population creates circumstances in which children have little value to the family, since there is little room for a garden plot or other forms of productive endeavor for them, and have great cost, since food and other necessities must be transported to the city. These economic pressures together with urban attitudes springing from other sources combine in enforcing a low birth rate.

The Effect of Change on the Social Structure and the Family

Our present value system is anti-totalitarian. A continuation of technological change in the direction of a more rapid growth in the efficiency of highly centralized, large organizations than in that of small and decentralized organizations may change this. Past movements have been antithetical to democratic values. The steam engine, which is much more efficient for large scale power production than for small, gave great impetus to the growth of large industrial enterprises. Transportation and communication, which once made the marketing of the produce of large scale enterprise expensive, have been continuously improved with the consequent reduction of this barrier to centralization.

Once the scale of enterprise was enlarged, research and development began which reinforced the trend. Small enterprises tended not to support individual research programs since saving of cost on a few units of product did not justify the expense. Large enterprises, in which a

small saving in cost on individual items meant very large total savings, found it economic to support programs directed toward the solution of the problems peculiar to their scale of operation as well as those common to all scales. As a result, technological change produced in their laboratories furthered the growth of efficiency of large scale enterprise relative to small enterprise.

From the social point of view, research which solves the problems of small enterprises may be as economic, or more, as that which solves the problems peculiar to large scale production. The total saving in cost or gain in value of product will be as large when small savings or gains per unit occur for the total product produced by *many* small enterprises as when it occurs for the total product of *one* large enterprise.

We must prevent our society from becoming an aggregate of a *few* large organizations if we wish to preserve our democracy and our freedom. The rise of Hitler in Germany was preceded and conditioned by the rationalization and cartelization of German industry and labor. Reorganization of research in the direction of aiding small enterprises is essential to the preservation of traditional American values.

Beginnings have already been made in providing research and development centers whose services are available to small enterprise. The Mellon Institute of Industrial Research, Battelle Memorial Institute, Armour Research Foundation, and Midwest Research Foundation are examples. By the use of these centers and by the use of research centers supported by the cooperative effort of many firms, such as those organized by the baking, the laundry, and the gas industries, research which is uneconomical for one small firm, but is worthwhile for several, may be undertaken. Specialized engineering firms also serve this purpose. Governmentally supported research centers could similarly devote themselves to such problems, as the Department of Agriculture now does.

Past inventions and improvements have not uniformly contributed to the decline of small scale production. The gasoline engine and electric motor have done much to preserve the family size farm and the small shop and to keep some production in the home.

Up to recent times, production was progressively moving out of the home and into the factory. Spinning and weaving were among the early casualties. Home canning, baking, clothes-making, laundry, and entertainment are among the more recent. The result was a deterioration of the economic basis of family life with the consequent decline in the birth rate and rise in instability in family relations. The family began shifting to an emotional base for its continued existence with a consequent growth in the role of romantic love. Whether this is an improvement is hotly disputed by those holding different value conceptions.

Recent inventions, such as the electric motor, the home laundry, the sewing machine, the deep-freeze, and television, are moving production back to the home and the family. Television alone has changed family living habits by leading husbands, wives, and children to spend 40 per cent more of their leisure time at home. Whether the total impact of these inventions will be sufficient to raise the value and reduce the cost of extra children to the point where the birth rate is affected remains to be seen. Whether the increased economic role of the family unit will reduce the divorce rate cannot be foretold. We may postulate, however, that a continuation of change in this direction certainly will not hinder movement along these lines.

The Effect of Change on the Likelihood of Continued Progress

Technological change which brings giantism not only imperils democratic values; it also signs its own death warrant. Social structures which are rigid and in which men are not free inhibit progress. Change finds it much harder to get itself accepted in large organizations since more

decisions are made by rule and less by re-valuation of possibilities. A large organization is operable only when a large part of its tasks can be put into a repetitive, unchanging form.

Not only is change less likely to be accepted in a giant organization; it is less likely to be accepted in a society composed of such giants. If there is only one decision-maker in an industry, a "no" from that one is the end of any attempt to introduce a new idea. The cracking process, for example, was turned down by the Board of Directors of the old Standard Oil Company. Had Standard Oil not been broken into several separate companies by an anti-trust decree, Dr. William Burton might not have found a new decision-maker to whom he could sell the idea. Similarly, the National Biscuit Company failed to use the band oven that was developed in its shop. Only after competitors began using it did National Biscuit take it on.

Technological change which tends to increase the scale of enterprise decreases the opportunity and likelihood of further change. If a nation is to maintain its avenues of expansion, it must develop the techniques appropriate to small scale production.

Has Change Been Good or Bad?

Because of its effect on population density, family life, personal relationships, and value orientations, the value of technological change has been questioned. J. S. Mill argued that "It is questionable if all the mechanical inventions yet made have lightened the day's toil of any human being. They have enabled a greater population to live the same life of drudgery and imprisonment, and an increased number of manufacturers and others to make fortunes. But they have not yet begun to effect the great changes in human destiny which it is in their nature and in their futurity to accomplish." At this point, a century later, the hopeful aspect of Mill's statement may seem closer to realization, yet we still see explosive population increases occurring in many places where technology is improved with the Malthusian consequences Mill dreaded.

There were values inherent in pre-industrial techniques of production which may have been unwarrantedly sacrificed. Gandhi argued for the retention of cottage industry to prevent the domination of life by the soulless rhythm of the factory and by unnecessarily created desires. His argument was convincing enough to lead the Province of Madras, India, to prohibit the expansion of textile mills.

Perhaps the heedless rush to methods which gave more product unnecessarily sacrificed values which could have been preserved. Perhaps we could have both had our cake and eaten it. In the case of India, some observers believe that reconstruction of capital markets, of distribution, and of technical education would make cottage industry economic. With the present situation, mill production is more economic for reasons which lie outside the choice between methods of production. If the services of a skilled marketing organization, skilled inspectors and supervisors, and a skilled purchasing agent were provided to cottagers, home production would become economic and the values of the old way of life would be preserved.

It may be argued that the depersonalization of his work and the loss of control over his work-setting has made modern man a ripe subject for the psychiatrist's couch. The performance of a small task, whose useful end is not apparent, under circumstances which may be arbitrarily changed because of what seems to be the whim of remote beings, may create a loss of any sense of an orderly, rational universe. Perhaps our society is sick, in the sense that it creates a high incidence of psychosomatic illness, because of the development of modern technology.

On the other hand, modern man is far more objective than his ancestors were. The outlook of the scientist and the engineer has percolated into many corners of the world. Authoritarianism is on the de-

fensive because men have learned to test the truth of a statement by examining the circumstances and experimenting where necessary. Only by learning to truly understand nature could man obtain dominion over her. The requirements for advancing technology discredited authority as a source of truth and gave man an attitude which, by extension into questions of social policy, may enable him to become master of his social environment. He may thus become able to devise the means for preventing the social eruption which would lead to his annihilation.

Sections and Branches

The **National Capital Area Section** of ASEE (covering Maryland and the District of Columbia) held the first meeting of its 1950–51 school year on Tuesday evening, October 3rd, in the Auditorium of the Naval Ordnance Laboratory, White Oak, Silver Spring, Maryland.

Russell B. Allen, Head, Civil Engineering Department, University of Maryland, Chairman of the Section, presented as guest speaker Dr. Thomas E. Hibben, Advisor for Foreign Economic Development, U. S. Department of Commerce, who adressed the section on "Point Four and Its Implications for Scientific and Engineering Education." Other program participants included Henry H. Armsby, Associate Chief for Engineering Education, U. S. Office of Education, and Vice-President of the Society, who brought greetings from the Executive Committee, and spoke briefly on "Federal Plans for Emergency Training Programs," and S. S. Steinberg, Dean of Engineering, University of Maryland, who reported on the Seattle Meeting of the Society.

The next regular meeting of the Section will be held on February 6, 1951 with George Washington University serving as host institution.

You Will Want To
Reserve This Date.....

JUNE 25-29, 1951

Annual Meeting

Michigan
State
College

East Lansing, Michigan

The Role of the Engineer in International Affairs*

By PAUL B. McKEE

President, Pacific Power & Light Company

Whatever the role of the engineer is or may be in national or international affairs, you share a great responsibility for his effectiveness. Perhaps it goes without saying that you have more influence than you realize on the character and thus on the careers and the future of the young men who look to you for training and inspiration.

It seems wise to create some limiting specifications within the broad subject assigned to me in order that we may come down to a practical and, I hope, interesting discussion of the subject with emphasis on the opportunity for the young men who are now preparing to play their part in the scheme of things. In the first place, I have assumed that we are to speak of American engineers in foreign service because it is the American engineer for whom all of us have the primary responsibility. Second, I have assumed that the world will continue at peace and that it is not the purpose of this discussion to consider the engineer in war, although no one will be more important if we come to the point where the fatal decision has been made to blow up one another and the world with atom bombs and other horrific instrumentalities.

A description of the achievements of the engineer of World War II, in the actual military operations in the great construction and manufacturing projects required to back up our field forces and in the procurement of strategic and essential materials both at home and abroad would require the writing of many volumes. Let us pray that while preparing for this eventuality our engineering talents will not be needed in this field.

On the contrary let us assume that the role of the engineer is to look and work for better standards of living and better human relationships and more and better things for more people throughout the world.

Further, I have assumed that any engineer trained in our great schools will expect to practice his profession in the atmosphere and against the background of our democratic and free-enterprise system where the efforts of the individual are to be rewarded in proper proportion to the energy and ability with which he conducts himself. Further, I have assumed that within these specifications you would like to have my idea of the kind of training and experience and general attitude which will make our young men of the greatest value in foreign service and enable them to achieve the best results for their employer, for themselves and for their country.

International Relations In Transition

There has been an astonishingly wide change in the outlook of the American people, with respect to our relations to foreign countries. The first World War and the depression succeeding and then the second World War have brought us forcibly to the realization of intimate and inescapable international relations. Any one who would have said 40, 25 or even 15 years ago that this country should in 1950 be spending billions annually in strengthening and supporting other coun-

* Presented at the General Session of the ASEE Annual Meeting, Seattle, Washington, June 21, 1950.

tries and peoples, would have been considered insane. There has thus been an awakening of the necessity of these close ties with the world at large. It has been realized that the ties to foreign lands are so close and so essential that reasonable wellbeing and safety for our country depend in increasing measure on the existence of corresponding conditions in the outside world.

This increasing intimacy of relation is in part the result of the rapid and general intercommunication and the great speed of transportation—as compared with conditions a very few decades ago. The expanding scope of the press and of the radio and the increasing utilization of air transport have been important elements in bringing various parts of the world together, in emphasizing to our citizens the element of foreign policy and of acquainting them with the working groups of the Government that have to do with formulation and execution of policy. Subgroups of Federal departments are stationed in Germany, Japan and many other countries.

Hence, there is more and more a call for men to represent the United States in foreign countries, in operations pertaining to politics, administration, business, engineering and construction. These men represent the Government itself, and commercial, engineering and construction interests. Hence, comes a special call and opportunity for young engineers to take up foreign service.

Work in other lands, with their broad background of history and culture, is attractive to certain men and women, in part because of the novelty and the variety and keenness of interest attached to it, and in part because of the broader opportunities and greater monetary returns. Until within a relatively short time, England and Germany sent out more of its young and vigorous men to foreign countries, but recently the United States, with its increasing participation in world affairs, is carrying out many operations and enterprises abroad.

Preparation for Engineering Abroad

How should we prepare these young men for work abroad? It seems to me we should recognize, in the first place, that mathematics and engineering and the various formulae under which we engineers proceed practically are the same the world over. Therefore, if one is to practice engineering abroad, he should first of all be given the finest and highest type of engineering education available.

It is seldom that a young man at the beginning of, or during, his undergraduate college career plans definitely for service abroad. Usually, at that stage he is simply training himself to do engineering work wherever it may be found. In my opinion this is a distinct advantage. In other words, from an educational standpoint the best possible basic training for work abroad is a sound and thorough knowledge of reading, writing and mathematics, plus a thorough groundwork in basic engineering principles. A good working knowledge of the English language and of the history of our country and at least a general understanding of the history of the world is also essential.

If during high school or college this candidate for future foreign adventure is fortunate enough to be stimulated into a real study of an ancient language such as Latin, it will serve him in great stead when it comes his turn to learn the language of another land. This is borne out by my own experience when it became necessary for me to learn Portuguese from scratch, as it were, at the age of 35. Without the foundation which comes to one through the study of an ancient language I would have been even more handicapped than I found myself to be. If the engineer going abroad knows the specific country in which he is to work, it is obvious he should have as much training in the particular language as is possible to get here at home. Certainly, at least a working knowledge of the grammar would be tremendously helpful. Any modern language in addition to English whether it be Spanish, Portuguese, French

or German, will be a great advantage, but it seems to me that Latin is essential.

In our own company it was our practice in Brazil to try to put the new and younger American engineers at work in the interior away from the large cities where there was little English spoken and where they had to speak the language in order to eat. In this way some of the more adaptable young men were able to gain a working knowledge of Portuguese in a comparatively short time. Once we outdid ourselves by sending a very promising young engineer into the interior where he took up his abode with a very fine family of "fazendeiros" (plantation owners). There he met a charming senhorita who could speak nary a word of English and they were married before he could speak a word of Portuguese.

When should the young engineer go abroad—immediately after leaving college or after some years of experience in some phase of his profession at home? My own experience indicates that a few years of practical work at home and a degree of seasoning is better. We are building so many plants and spending capital money in such large magnitude and operating so many facilities in this country as compared to the volume of similar undertakings in other countries, that a man can gain experience here faster than he can anywhere outside of the United States. All of us know out of our own past that the place to get experience is where the work is going on. Therefore, I recommend that the young engineer planning for work abroad serve his apprenticeship at home.

Given a good practical, general and engineering education and a few years of experience at home, a workable understanding of history, a person should be ready for his adventure abroad provided, first, that he is interested in going abroad; second, and perhaps more important, that his family is interested in going abroad and that he and they have a human outlook and lack of prejudice which make them able and willing to work with people. It should be remembered that the folks with whom they come in contact will not always appear to be the kind of people whom our candidate and his family may have met on Broadway or Main Street or with whom they may have gone to school and college. Experience will show that way down deep human nature is pretty much the same the world over, but environment and custom change the outward appearance and point of view of the individuals. Unless the candidate's family background and character and education make for a desire to understand and get along with people, then the family had better stay at home.

Personal Adjustments are Important

There are many fields of international service where physical comforts are at least the equivalent of those found in our own home town; on the other hand if one is to fulfill his destiny as a real adventurer into foreign service, he must be prepared for some physical discomforts and must develop within himself the resourcefulness and contentment of mind and spirit to adjust himself to new and sometimes less comfortable situations.

Again at this point let us not overlook the fact that if this particular candidate for fame happens to be a married man with a family, they too must be prepared for an adjustment of this kind. I am sure than anyone engaged in engineering work outside of this country or supervising their work in the foreign field will agree with me that while the characteristics of the man are important, the ability on the part of his wife to get along under new and strange conditions in a foreign land is even more important.

While what I am about to say is obvious, I believe it is worth the emphasis which comes from repetition to say that all of us have seen good men in our own country held back by unfortunate family situations and mediocre men helped to succeed by the right kind of family relationships. And, while this is true at home, it is vital abroad.

Again, drawing on my own experience,

after several mistakes in the business of bringing men to foreign service without having a chance to give his wife and family an opportunity to know what they would be up against and without the chance to meet the family in the United States before they went abroad, we made an absolute rule that no one could be employed or taken from available candidates in the United States until some senior member of the company, with ample foreign experience, had a chance to discuss the situation thoroughly with all members of the family. When you remember that it requires a substantial sum measured in the thousands of dollars to move a family from home to a location abroad and when you realize that one mistake costs great expense and delay, I am sure the need for this precaution will become apparent.

I believe that we of the United States are not yet sufficiently conscious of the simple points which I have just made, and that a nationwide program should be developed under which men and women with successful experience abroad could be available as counselors both to potential employers of younger people and to candidates for service beyond our boundaries. I submit that this would be a most worth while function and, if done on a sufficiently broad scale and by people of outstanding ability, great benefit to all should be gained thereby.

Let us now assume that we have our candidate well educated and well grounded in the first few years of his practical engineering experience. Let us further assume that an opportunity comes to him to go abroad. What will he need to do? And what will he be up against?

Probably the first thing some well-intentioned adviser will tell him is, "When in Rome, do as the Romans do." My own experience indicates that this is the kind of advice which comes from lack of understanding and experience on the part of the adviser. When my opportunity came to go abroad, a wise old counselor said to me, in talking about the matter of behavior in another person's land, urged me, above all, to read again Polonius' advice to Laertes, which you will remember is as follows: "to thine own self to true, and it must follow, as the night the day, thou canst not then be false to any man." Then he added, above all just be yourself.

We in the United States have developed a fine habit of life and a high level of business and engineering integrity which will command respect abroad if permitted to become evident in an intelligent manner. I certainly would advise any young man who is going beyond our borders to remember the best things of our civilization, take them with him simply and with humility, and not to try to dress himself up in a lot of strange and unfamiliar customs and mannerisms which will be of no benefit to him and will merely tend to make his friends abroad think that he is a bit queer.

Human nature is the same the world over. Respect for integrity, proper behavior, and decent humility is of value no matter where you may be. It is quite true that customs vary. In South America, for instance, one cannot always proceed with the briskness and determination to get quickly to the point as may be done here at home. Naturally, there are many other modifications to one's normal way of life at home too numerous to give in detail here, but which quickly become apparent to the person of adaptability. Nevertheless, the fundamentals are the same, and I am certain that the best advice that can be given to a young man about to go abroad is just to be his natural, decent, American self.

Learn the Language and Customs

As I have mentioned before, it is my opinion that the next most important move is for the young man to begin a diligent and careful study of the language of the country in which he is to work. Every spare moment should be devoted to this job and he should make it apparent to his new associates that he is doing his level best to learn their language. They will not expect him to be proficient overnight,

but they will expect him to try his best to master their language.

In my opinion the next in importance is for the individual to begin and carry through a careful study of the history and the fundamental laws and customs of the country in which he is to work. Also, he should make an earnest effort to learn and understand the geographic and climatic conditions and resources of the area. Information about all of the physical and philosophical characteristics are available in the literature and through conversations with people he will come to know. Everyone the world over likes to talk about the land of his birth and there is a veritable ocean of data of this kind ready for the person who evidences a proper interest. I am sure that in most cases this sort of study will bring out the good points—and every land has many of them—and will set up the danger signals.

In all of this there are a few legitimate tricks which will be learned quickly by the discerning individual. For instance no one in the world likes to be called a "native." There is a connotation to that word which is bad and the use of it should be avoided like the plague. Neither does the other person like to be told that his way of doing things is not good because "it is different from the way we do it in the States." He should try to find the good things which people are doing and emphasize them, at the same time recognizing the weaknesses, and as he would do at home try his level best to offset them and overcome them.

Unwarranted interest in the politics of the other fellow's country will constitute a bad blunder. When we go abroad as guests of another land, it is not our function to tell them how to run their government. That is their business. To do otherwise is a violation of a principle which was enunciated by a famous engineer about the time I was starting my own career. His "principle" was simple, but I am sure you will all agree it was thoroughly sound. "Never delegate authority without an equal percentage of responsibility, and never accept responsibility without corresponding authority." If one interferes in politics of another land, he is attempting the exercise of authority without being confronted by the corresponding responsibility of citizenship.

Difficulties Often Encountered

Now as to physical operations: In most cases the engineer abroad is much more on his own than he would be in our great land which is full of railroads, telephones, highways, factories, and all the other facilities which make for speed and ease in the carrying on of engineering and construction work. For instance, if he forgets to order a particular piece of machinery essential to his plant's operation, he can usually get it from the factory by airplane or otherwise in a matter of a few hours. On the other hand, most countries abroad are not so adequately equipped with transportation, communication, and manufacturing facilities and therefore engineering and construction require very careful planning ahead. Failure to do so may result in costly and unfortunate delays. He will also need to understand all of the possible delays which will result if he fails to familiarize himself with the rules and regulations in the customs house, in building codes, and in other similar restrictions. We are all confronted with corresponding regulations at home, but they raise much greater mental barriers abroad if we fail to familiarize ourselves with them.

If he is to carry on his work profitably, economically, and expeditiously, he will need to understand how to use the materials and the personnel resident in the country of his adoption. This will require patience and the example of hard work. It is essential that the dignity of the human being in whatever field from laborer to capitalist be kept constantly in his mind, and he must remember always that he is the stranger and not the people with whom he is working.

Engineers are Ambassadors of Good Will

I am sure that all engineers and engineering executives whether in this country or elsewhere, must think of themselves as practical teachers and educators. If we are to get the right kind of assistants to carry on any sort of enterprise, we must spend a good part of our time educating and stimulating the men and women who will work with us. To the engineer who is to work abroad, the development of this ability and characteristic is even more important than it is at home. He must make his new friends feel that he will do anything he can to bring to them the knowledge and experience which he has gained in this great United States of ours, in return for which they will help him to gain an understanding of the conditions under which they live and work and of their language. Happy will be the man working abroad who finds within himself the abilities and energies to do this very interesting and worthwhile educational job. It will be helpful to him and it will also be of great value to our country. While we have diplomats and specialists abroad who are charged with the responsibility of seeing to it that our point of view and way of life are properly presented; nevertheless, each one of these young engineers who go abroad can be invaluable as ambassadors of good will.

How wonderful it is that an American going abroad has the right to carry with him the conviction that he springs from a country which in the comparatively few years of its existence has done more to develop the rights and freedom of the individual than any other nation in the history of the world. That he may carry with him the realization that his own country has set a standard of development and technical performance which is unequaled.

Naturally, those of us who stay at home must do our utmost to preserve our own way of life in his absence, but on the other hand he can be of great help by bringing to other countries, ideas which will gradually make it possible for them to approach our high level of accomplishment. In this effort the engineers will play a prominent part, as they have in our own country's development. Naturally, the engineer cannot be expected to do it alone —he must have the help of the medical profession, the legal profession, statesmen, diplomats, businessmen, and in fact our entire citizenry.

You, I am sure, have come to the conclusion that the United States must assume its proper position of leadership and cannot forever exist as an oasis of prosperity in a desert of misfortune. It is my belief that we must work at this job in a practical manner and I repeat for emphasis that the engineer will have a great part in helping to win the game against the forces which are trying to take our position of leadership from us. We have demonstrated at home that our system will bring the greatest good to the greatest number. If we can help do a similar job abroad we are safe.

Gentlemen, you who have so successfully trained the present generation of engineers and who now have before you the great opportunity and the great responsibility for training the men of the future upon whom we must rely for our success at home and abroad—I salute you!

A New Approach to the Doctor's Degree for Engineers*

By D. H. PLETTA

Chairman, Department of Applied Mechanics, Virginia Polytechnic Institute

Individual members of this Society have for many years endeavored to change the engineering curriculum. Some of the suggestions made decided improvements; others were perhaps questionable; all were no doubt sincere. The clamor for change has increased recently, due in part to the desires of some to include more of the humanities, and of the realization of others that a broader foundation in basic science coupled with more training on a graduate level was an inescapable necessity.

The approach suggested in this paper encompasses both of these aims to a greater extent than do present curricula, but would necessitate considerable change in these before adoption could be effected Briefly the proposal is this: stop the patchwork bolstering of the curriculum and integrate the overall educational requirements for true professional stature, as the other professions have done. The plan would include a four year course in the humanities, basic engineering science, and personnel management, terminating with a B.S. Degree. This should be followed by two more years of specialization in one of the engineering branches on a high graduate level for those who have the ability, and culminate in a one year internship, a Doctor of Engineering Degree and professional registration (see Fig. 1).

Novel Features

This proposal breaks with the past, for it reverses the trend toward specialization too early in the engineering course, which has resulted in the fragmentation of our profession, certainly with questionable effects. But before describing this 4–2 plan in more detail, it might be well to discuss the reasons prompting such a change.

Doctoral candidates in engineering today complete the *equivalent* of nine academic years of work for a Ph.D. as compared to *seven* for a Ph.D. in Arts. This extra work may be accounted for by comparing the 225 quarter credits required for a B.S. in engineering with the 180 quarter credits required for a B.S. in the arts, and by adding another year for language requirements which the engineer must make up, but which is included in the arts students B.S. curriculum. I see no way of reducing this total of nine equivalent years of work except by deleting some professional work or the language requirements. Neither is desirable but some reduction seems to be in order.

The engineering profession has long known that graduates of its four year courses were not ready to practice on a full professional status upon graduation. Industries have sought to implement this deficiency by training courses and restricted internships of varying length. Colleges have likewise established additional training on a graduate level, and have continually added to the curriculum, channeling this course content into ever narrowing specialties. State licensing agencies in increasing numbers, are requiring a period of acceptable experience after college for full professional recognition. Where has this haphazard growth led the profession?

* Presented at the April 1950 meeting of the Southeastern Section, ASEE at V. P. I.

We might begin by comparing our profession with those of law and medicine. Table I lists certain significant deficiencies in engineering. Although engineering has been taught in the United States on a collegiate level for 122 years, as compared with about 180 years for law and medicine, we have lagged behind these professions in establishing licensing laws, conceiving an integrated professional training program, founding a national professional society, accrediting curricula and establishing a National Board of Examiners. The most glaring comparison is our reticence to become licensed; only 42% of those now practicing are legally qualified compared with practically 100% in law and medicine.

This reticence is, in no small way, due to early specialization with its attendant lack of esprit de corps. Although we did not fight each other, we certainly did not begin helping each other until recently. Only 15% of us are active in coordinating our common professional interests, and few indeed protested the labor bill in the last Congress which would have subjected us to CIO or AFofL unionization. Engineers have rendered truly astounding technical service to the public, but if you believe we have achieved comparable recognition with the other professions in the mind of the public, you should read "Public Relations Interpreted as Good Engineering" by Harry W. Lundin in the February, 1949 *American Engineer*. The public thinks we drive trains, and rates our profession a poor tenth when comparing the contribution that groups like doctors, lawyers, farmers, government employees, etc., have made to our standard of living.

The engineers' specialization has likewise served as a psychological block, preventing his freedom of movement from one technical field to another because he was unaware of his abilities, meager as they were in some engineering fields. For instance, many civil engineers did heroic service during the last war as structural engineers in the aircraft industry. But their transition was painful until they

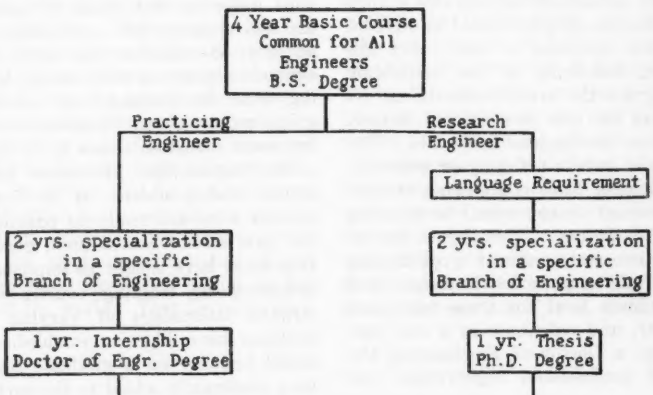


FIG. 1.

TABLE I

	Medicine	Dentistry	Law	Engineering
First Licensing Law	1760	1841	1890	1907
First College Course	1765 (U. Pa.)	1840 (Balt.)	1779 (W. & M.)	1828 (Rensselaer)
2-4 Plan Approved by Prof. Society	1918	1937	1921	?
Founding of Prof. Society	1847 (AMA)	1859 (ADA)	1878 (ABA)	1934 (NSPE)
National Board of Examiners	1892	1883	1931	1920
Prof. Society Accrediting of Curriculum	1907	1909	1921	1936
Licensed Individuals	165,000	77,000	180,000	150,000
Practicing Individuals	165,000	77,000	180,000	350,000
Membership in Professional Societies*	138,000	71,000	42,000	22,000

* Membership restricted to legally qualified individuals.

Data in the Table I represent the best available information. Individual entries give statistical data for the 1940–50 decade, but do not necessarily coincide for any one year. The entries should, therefore, be regarded as being only approximate.

realized the basis of mechanics fundamental to such design in any engineering field.

I am not one who believes that engineers could, or should, run this so-called civilization. Our *first duty* is to *train technically* competent engineers, but early specialization tends to obscure our overall *technical* responsibility of safeguarding public safety and health. Our machines freed man of slave labor but maimed some because safety measures were installed too late. We prolonged man's life by refrigerating his food and purifying his drinking water, but our industries then polluted the air he breathes and the streams in which he swims. We "deskilled" workers and wondered why they no longer took pride in workmanship. We improved our productive efficiency and were accused of the "speed-up."

Undergraduate Program

The foregoing thoughts may explain in part the somewhat unorthodox program proposed in what follows. First, in order to correct our tendency toward over specialization in the first few years of professional education, I believe these should be generalized technically so as to give all engineers the broad *working* base in the several branches of engineering which industry seems to favor. This curriculum is outlined in Table II. Note that mathematics has been increased beyond calculus to include ordinary and partial differential equations, advanced calculus, vector analysis and perhaps an introduction to tensors. This added training would facilitate and streamline the teaching of advanced technical and graduate subjects. With this background, a four year graduate would then again to able to digest the more advanced papers now published in his own field. Few four year graduates today are able to read highly mathematical papers currently included in the ASCE, AIAS, and ASME Transactions. Similar training in all basic engineering science would likewise increase one's pro-

TABLE II

BASIC FOUR YEAR ENGINEERING CURRICULUM

	Quarter	Credits
I—Cultural Subjects		
A—English (Composition, Rhetoric, Public Speaking, Technical Writing, Literature)	18	
B—Humanities (History, Philosophy, Psychology, Economics, Law)	21	39
II—Sciences		
A—Physical Science (Chemistry, Physics, Geology, Mats. of Engr., Metallurgy)	32	
B—Mathematics (Algebra, Trigonometry, Anal. Geom., Calculus, Differential Equations, Advanced Calculus)	40	72
III—Engineering		
A—Sub Professional (Drawing, Desc. Geometry, Surveying)	12	
B—Professional		
a—Mecahnics; Strength; Fluid Mechanics; Structural Analysis	22	
b—Design of Structures and Machines	15	
c—Electricity—AC, DC and Electronics	15	
d—Heat Transfer—Thermo., etc.	15	
e—Production, Personnel Management, etc.	15	
f—Electives	15	109
		220
GRADUATE TRAINING (C.E.—Example)		
IV—Fifth Year		
A—Transportation (Highway, Railway, Water, Airports, Pipeline)	9	
B—Sanitary (Water Supply; Sewage Disposal; Bacteriology; Hydrology; Water Analysis, Microscopy)	12	
C—Surveying and Mapping (Topographic; Route; Photogrammetry; Geodesy; Law)	9	
D—Construction (Estimating; Soil Mechanics; Cost Accounting; Specifications)	12	
E—Design (Indeterminate Structures; Design; Water Power)	12	54
V—Sixth Year—Design Option		
A—Elasticity and Plasticity	12	
B—Vibrations	9	
C—Fluid Mechanics	9	
D—Tensor Analysis		
E—Electives	10	45

ficiency in these specialties. Civil Engineers, for instance, are using electronics for triangulation in surveying and depth gaging of harbors. Electronic devices are fast becoming controlling factors on production lines. An understanding of electronics is essential to all—not proficiency for tube or circuit design, but plain conversant knowledge.

Design could likewise be taught on a completely revised basis by emphasizing the basis of mechanics and using illustrations from all fields in the simple design of machines, buildings, planes, vehicles, etc. Heat transfer could cover the thermodynamics, not only of perfect gases and vapors, but also of liquids and briefly of solids.

Since engineers must assume technical and administrative leadership in industry, it seems absolutely essential to include some training in this field too. 'Tis often

said, "leaders are born—not made." It helps to be born gifted, but the principles of leadership are well known and can be taught. They have in fact been taught at our own Military and Naval Academies for years. Why not at civilian schools too?

Successful completion of such a course would leave an individual well qualified to pass preliminary examinations for the professional engineer's license, and to improve by individual study in any technical field of his own choosing—if he had the determination. He would be well trained for future administrative work. Subsequent academic work should, I feel, be split into one of two categories here but admission should be restricted. The man interested mainly in research could then pursue and earn a Ph.D. Degree as he does now (Fig. 1). For the practicing engineer, and most engineers practice and seldom engage in real research, I believe the alternate plan outlined below would be more suitable.

Graduate Program

Supplementary specialized instruction should follow the four year program in another two years of study. The first of these would allow coverage of the several fields of a particular branch of engineering. One electing civil engineering for instance, would study the broad fields of sanitation, surveying and mapping, transportation, construction and structural design. The sixth year would then be devoted to a further specialization of one of these, such as structures, and include elasticity, plasticity, vibrations, fluid mechanics, and highly indeterminate structures.

Successful completion of these additional two years of professional training would entitle the individual—not to the necessity of pursuing a thesis in some narrow field—but to a broad internship. He would visit large industrial and governmental research laboratories for perhaps several months, and gain a better insight into overall research programs and techniques than by conducting his own thesis. He would also be apprenticed to production managers and corporation presidents as their special assistants for short periods of time to see how the "top brass" operates. He would spend some time on construction jobs, on production lines and in design rooms.

This period should be labeled an internship for this word has been already accepted by the public as connoting completion of an academic professional course of study, and initiation of professional practice under *legally* qualified practitioners.

A treatise on this internship marking the seventh year, embodying consideration of technical and human problems should entitle a man to the Doctor of Engineering Degree. I do not feel that titles like C.E., etc., suffice in the public mind, for our own colleges have been too prone to vary the standards in the past for this degree. Some schools had, and still do have, very rigorous standards † for a Professional Degree, but none require a seventh year of internship to my knowledge. Furthermore, the public now considers a doctorate title synonymous with true professional stature.

These seven years of training would then allow a candidate to obtain his professional license without difficulty, and examining boards could waive the usual four year in-training periods. Industry might still not trust the judgment of these inexperienced products with top positions of responsibility, but the public at least might think of them as professional individuals.

The suggested program with its four year course, two years of graduate work, a year's internship, a Doctor of Engineering Degree and Professional License might encourage the public to grant engineering its merited professional stature.

† Stanford and M.I.T. have six year courses.

An Interpretation of the Manifesto*

By C. J. FREUND

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The cooperative system of engineering education has grown up; has even attained middle age. The cooperative colleges of engineering have adopted a statement of policy, and that proves the maturity of the system.

A manufacturing corporation, a university, a club, even a new government, almost any type of enterprise, seems to develop according to a familiar pattern. In the early years the enterprise displays great vitality. The operators are eager and exuberant, although they make mistakes and are less efficient than they might be. In time the first enthusiasm wears off a little, and the operators begin to suspect that they had better mingle wisdom and thought with hard work and optimism. Problems arise which they did not notice at the start, or which did not exist. The operators seek formulas to assure permanence and stability.

After some trying years of experience and experiment, they construct basic rules to guide them when they encounter such complex difficulties that simple and obvious solutions are impossible. By the time the operators have drawn up these basic rules—we call them policies—and especially after they have published them, the public is quite certain to recognize that their enterprise is firmly established.

The cooperative colleges have published their policy, and consequently the cooperative system is a firmly established institution. The statement of policy is called "The Cooperative System—a Manifesto." The Cooperative Engineering Education Division of the Society adopted the policy in its meeting at St. Louis in 1946, and it was published in the JOURNAL OF ENGINEERING EDUCATION for October of that year.[1]

It is this Manifesto which we shall consider for a few moments.

The Selection Process

We hardly need to go over all of the Manifesto: besides, there isn't time enough. We had best confine ourselves to a few topics in the Manifesto which pertain especially to what is going on at the moment in engineering employment and in engineering education. And we might as well begin by looking at the cooperative plan from the viewpoint of the man who hires the boys who graduate from our colleges.

Every employer is concerned, of course, about working capital, sales, an efficient plant, good will and the like. But every intelligent employer knows very well that he can survive in competition only if his men are more competent than the average of his competitors' men. Hence it is that recruiting officials who visit the colleges are always looking for graduates of superior talent and personality.

How does the recruiting official usually select the graduates? All of us know the procedure. The student may write a letter of application. He may fill out a form with detailed information about his education, career and background. He may complete an aptitude or psychological test. He may have a fifteen minute interview with the recruiter, during which he can hardly be quite himself. And the

* Presented before the Cooperative Engineering Division of the ASEE at the Annual Meeting, University of Washington, June 19–23, 1950.

[1] XXXVII, 117–34.

recruiter may inquire about him of the professors or of the college placement officer. Occasionally he may spend a day or two inspecting the prospective employer's plant or visiting in his home office. This way of doing it is as effective as circumstances permit, in most cases, and reflects high credit upon the judgment and the resourcefulness of the recruiting officials. But the method is comparatively superficial, and it couldn't be otherwise on account of its inherent limitations.

As explained in the Manifesto, the employer of cooperative students does not have to depend upon letters of application, ten minute interviews and aptitude tests when he hires graduates. He chooses them after a trial period of employment in his plant, and he is quite likely to pick the right men. He has had the opportunity to observe their practical intelligence at work, which is something quite different from schoolroom proficiency. He can find out if they maintain their interest in his employees and his plant after the first novelty has disappeared. He can discover how they get along with engineers, superintendents, foremen, and workmen, including those with cantankerous dispositions.

Experience and Practice

Now I suggest that we fix our minds upon that most pleasing phenomenon, the superior student. We all know the type. He is a joy to his faculty, a leader among his fellows and a challenge to the recruiters who come around. Let us assume that this superior student gets a class assignment to design a fan and a motor to ventilate and remove moisture from an underground storage space. After some weeks the boy turns in the design. The professor checks the amount of air and water the fan can handle, the blade contours, the selection of bearings, the brackets and their capacities, the material specifications and much besides. He finds that all are quite correct and the boy gets a grade of A.

This class design is good enough, as far as it goes; it is acceptable within itself, so to speak. But nobody investigates whether it meets a number of external requirements, and nobody can, in a college of engineering.

The practicing or employed engineer has to worry about matters which the student, or even the professor, may never think about. Will the fan be noisy? Will it vibrate badly? The engineer may not find out until the first one is built. He has to specify materials which are readily available, and he had better know that they will continue to be. He will have a hard time defending forged blades in a plant equipped principally with presses. The pattern and foundry superintendents may go into an uproar about the cost of making up the brackets. The engineer must try to introduce parts into his design which are in production already for other purposes and regularly kept in stock. And most important of all, he must design something which the customer wants, and for which he is willing to pay enough to cover all direct and indirect costs, and a reasonable profit.

It is practically impossible to include any of these considerations in a college design course; there are some things one just has to learn by experience. And this is only one very ordinary example of the countless practical requirements and limitations which have to be recognized in every branch of engineering practice.

Cooperative employment is one way, and an excellent one, for students to acquire the practical outlook. After some months of employment in a machinery building shop, the cooperative student instinctively knows that good design requires much more than functional performance and simple specification of materials. Of course, cooperative employment is not the only means to this end. Students in continuous, conventional colleges of engineering may gain practical experience during summer vacations, or after they graduate, but most of them don't. It is never easy to find just the right kind of summer job, and parents,

doting aunts and uncles, and girl friends frown upon manual work after graduation; and so do the boys.

The Problem of Assimilation

Engineering graduates encounter jealousy and pride of status when they "break into" shop or office. It is hardly to be expected that the practical veteran and the technically trained upstart will get along together. The veteran fears that the upstart will overreach him by superior education; the young engineer fears that the veteran will thwart him as a highfalutin outsider.

The cooperative system is a natural solution of the problem. The old timer really does not resent the young engineer's getting to the top of the ladder, provided he climbs in regular succession from each rung to the next. What the old timer does resent is any attempt by the engineer to outsmart his less fortunate fellows who have to depend on steady labor to reach the top.

The cooperative student has been a workman in the plant. His fellow employees have seen him operate machine tools or presses, repair hoists, rebuild open hearth furnaces or engage in common labor. If his speech and deportment are judicious they may not even know that he is a student. If he is later promoted to an engineering or supervisory job, they are likely to concede that he has earned the promotion by a proper apprenticeship. Indeed, they may even be proud of him as one of their own who has made his mark.

Science and Engineering

It is easy for the cooperative student to understand the difference between the engineer and the scientist.

The scientist became the civilian hero of the war, and has remained a popular American hero ever since. Scientific research won the war, we are told. But engineers had a large hand in the business. In fact, the scientist without the engineer is helpless to create machines and structures. However, the writers, lecturers and commentators have spun so much glamor about the scientists that many engineers wish they were scientists, and some of them rather imagine that they are at least semi-scientists.

This, of course, is a mistake. The functions of the two are altogether different. The scientist explores for new information or knowledge; the engineer applies the new information or knowledge to improve the standard of living in the community. The scientist experiments in heat, dynamics and metallurgy, and deposits the reports of his findings in the libraries of the world. The engineer reads the reports and makes use of the information to design and construct a more efficient Diesel or jet engine. The scientist is essentially a thinker and a scholar; the engineer is essentially a maker, an operator and an administrator. The scientist and the engineer are quite distinct, although in the every day working world it is not always easy to know which is which.

But the engineering student has to learn which is which. If he is afterwards to perform his proper function, he certainly must know just what that function is.

The cooperative student in shop or engineering department learns to appreciate the engineering operations which result in the brightly painted rotary pumps, switchboards, machine tools or excavators waiting in their crates on the shipping platform of his plant. And he naturally concludes that altogether different operations result in documented research reports on the library shelf. It does not take the cooperative graduate half a lifetime to understand his place in the scheme of things.

Conclusion

Let me repeat that this has not been intended by any means as a review of the whole Manifesto. It has been intended merely to suggest how the Manifesto bears upon two matters which have captured the attention of engineering em-

ployers and educators: the assimilation of young engineers to their first employment, and the accelerating ascendency of science.

In conclusion, perhaps we should remind ourselves that the cooperative method of engineering education has no unique, major objectives of its own. The auxiliary objectives, and obviously the procedures of the method, differ from those of the conventional, continuous colleges, but the basic aims are the same. The American Society for Engineering Education has adopted scientific-technological and humanistic-social aims for engineering education. We all know them very well. They were published in the JOURNAL OF ENGINEERING EDUCATION for March, 1940.[2] To quote from the Manifesto, "The cooperative colleges of engineering accept these aims, and declare them to be their own."[3]

[2] XXX, 563–64.
[3] *Op. cit.*, 119.

Candid Comments

My attention has recently been called to an error in the article "Visualization of Fundamental Principles in Elasticity Using Rubber Models" in the May issue of THE JOURNAL OF ENGINEERING EDUCATION. A correction would make this report of considerably more value to others.

The rubber compound used in making a model is said to consist of natural rubber, 28.5%; fillers, 57.3%; vulcanizer, 8.6%; sulfur, 3.1%; oils, 3.5%. Converted to 100 parts of rubber, the basis used by rubber chemists, this becomes rubber, 100; fillers, 201; vulcanizer, 30.1; sulfur, 10.8; oil, 12.3.

If the term vulcanizer is used to mean accelerator and the amount shown is correct, the compound is impractical. These materials are seldom used in excess of 1 to 2 parts and never in amounts as high as 30 parts. The amount of sulfur used is excessive and will result in poor physical properties in the vulcanized compound. The amounts of oil and fillers are also unnecessarily high.

Yours very truly,

RALPH F. WOLF
Manager, Compounding Research, Pittsburgh Plate Glass Company

Results of Questionnaire Regarding Graduate Degrees in Chemical Engineering

By THOMAS E. CORRIGAN

Assistant Professor of Chemical Engineering, West Virginia University

In a recent survey of several graduate schools in Chemical Engineering, a questionnaire was sent out to ascertain current policies in the granting of the Master's and Ph.D. degrees in Chemical Engineering. This is a brief summary of the results of the survey.

Of the schools reporting, nine require a qualifying examination for candidates for the M.S.Ch.E. degree, and fourteen departments have none. The subjects covered in those schools requiring qualifying examinations are varied. In the majority of cases the examinations cover undergraduate and graduate chemical engineering courses and, in addition, the student's minor subject (where a minor is required). Some of the specific subjects covered are: Unit Operations, Industrial Chemical Calculations, Stoichiometry, Applications of Physical and Organic Chemistry to Chemical Engineering and Chemical Technology. The time allowed for the examination varies from four to twelve hours. Of the nine schools reporting use of the qualifying examination, six use a written examination and two have an oral one. In one department, both a written and an oral examination are given.

The policies seem to be fairly uniform in the requirement for a Master's thesis. Seventeen of the schools reporting require a thesis and in three others a thesis is optional but highly recommended. In three additional institutions none is required.

In the schools where both Master's and Ph.D. degrees are given, four require that the candidate obtain a Master's degree as a prerequisite to the doctorate. In four other departments this procedure though not required is highly recommended. In fifteen colleges the M.S. degree is not required as a prerequisite. Thus, there is some difference in procedure in this requirement.

The departments are fairly evenly divided in the matter of splitting the student's program into major and minor subjects at the Master's degree level. In nine schools the student must so divide his course work. In two others, this method is recommended but not required. Twelve departments do not require the division into major and minor fields.

For the Ph.D., however, sixteen schools divide the student's courses into major and minor fields, and three do not. Of this sixteen, five require two minor fields. Four of the schools replying to the questionnaire do not grant doctorates in Chemical Engineering.

Only one institution allows complete freedom of choice to the student in selecting his course. Twenty-one of the schools have a program in which some of the courses are required and some are left to the choice of the student under faculty supervision. In one institution the choice of the student's courses is made by the staff.

In conclusion, it should be noted that the sampling of the schools was small because only 55% of the questionnaires sent out were returned. However, the replies represent a cross-section group both from the points of view of size of the institution and section of the country. It is hoped that this summary will be useful as a step toward greater uniformity of standards in graduate schools in chemical engineering.

Laboratory Demonstration Experiment—A Link between "Fundamentals" and "Applications"

By D. ROSENTHAL and H. BAER

Department of Engineering, University of California, Los Angeles

1. *Introduction:* One of the avowed purposes of Engineering Education appears to be the teaching of the fundamental physical and chemical principles and laws as they apply to the engineering practice. In accordance with this purpose the student is first exposed (usually in the sophomore and junior years) to various courses, such as Mechanics, Strength of Materials, Thermodynamics, etc. in which the emphasis is on Fundamentals. To be sure the Fundamentals are slanted toward engineering applications, but the latter are generally treated as illustrations of methods of solution rather than as an aim in itself. The true applications come later. They are the subject of separate courses (usually in the senior year) known as: Structural Design, Machine Design, Unit Operation, etc. Not only are the Fundamentals and Applications taught separately, but as a rule they are taught by different instructors. This in itself is not a bad practice provided the two groups of instructors see eye to eye and work as a team. In the past the teamwork left much to be desired. In the cases in which the "Fundamentals" were treated with the necessary mathematical rigor they were entirely ignored in the "Applications," partly because the instructor in charge scorned at the "high-brow" mathematics, partly because he had more faith in his experience than in the underlying principles. As a result the student left the school under the impression that the "Fundamentals" were just a mental drill necessary for the attainment of the degree, but with no relation to the practice of the engineering profession. Under the impact of modern science this attitude no longer exists either with the instructor in charge of "Applications" or the student, but the necessary link between the "Fundamentals" and "Applications" is often missing in the instruction. A point in case is the relation between "Strength of Materials" and "Machine Design." It has been the authors' experience both as instructors and students that in the mind of the student only a tenuous link exists between these two subjects. To be sure the student

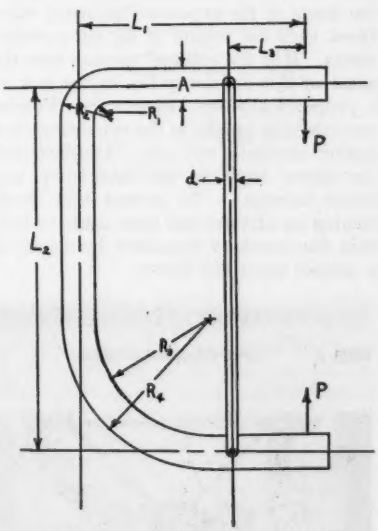

FIG. 1.

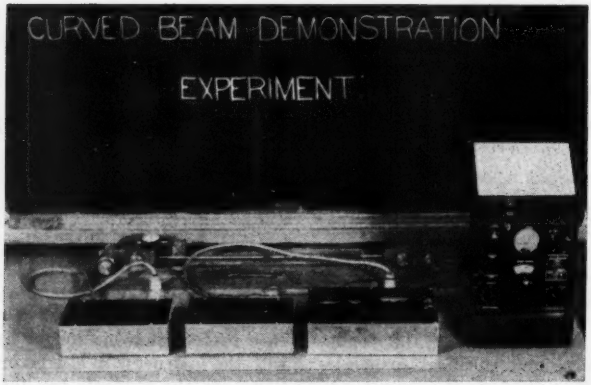

FIG. 2.

knows that the design of some of the machine parts is based on formulas of "Strength of Materials," but he is usually unaware of their limitations, and he is generally incapable to apply the methods which lead to these formulas. As a result, he is at a loss to explain the discrepancies between theory and experiment or assess the limits of the experimental error, when faced with the results of actual measurements. It is the authors' opinion that the cause of this deficiency lies in the lack of a proper transition between the "Fundamentals" (as taught in the sophomore and junior courses) and the "Applications" (as given later in the laboratory and senior courses). To correct this shortcoming an attempt has been made to provide the necessary transition by means of a scheme described below.

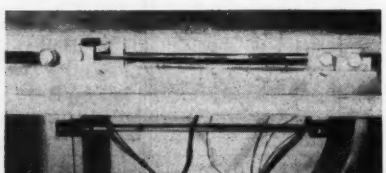

FIG. 3.

2. *The Laboratory-Demonstration Experiment:* The scheme consists of having the student solve a problem at various stages of idealization: from its theoretical inception to its industrial realization.

In the first stage the problem is in the nature of a computation. It is merely an application of principles and laws expounded in a theoretical course. In the second stage the analytical solution is obtained experimentally on a model reproducing all theoretical assumptions as closely as possible. In the third and final stage the experiment is carried out on an existing industrial system or machinery. This last step no longer forms a part of the "Fundamentals." It appears in a later year as a part of "Applications," and the experiment is performed not as a check of the theory, but as an inspection or test of the system or machinery.

The first and third stages of the scheme are not new. They have been improved continually. Thus, in the first stage classroom demonstrations, sometimes of remarkable simplicity,[1] and devices for visualization of great ingenuity [2, 3] have been

[1] R. S. Hartenberg, *J. of E. E.*, Vol. 40, p. 430.

[2] A. J. Durelli, C. H. Taso and B. H. Jacobson, *Ibid.*, p. 525.

[3] A. D. Moore, *Journal of Applied Physics*, Vol. 20, p. 790.

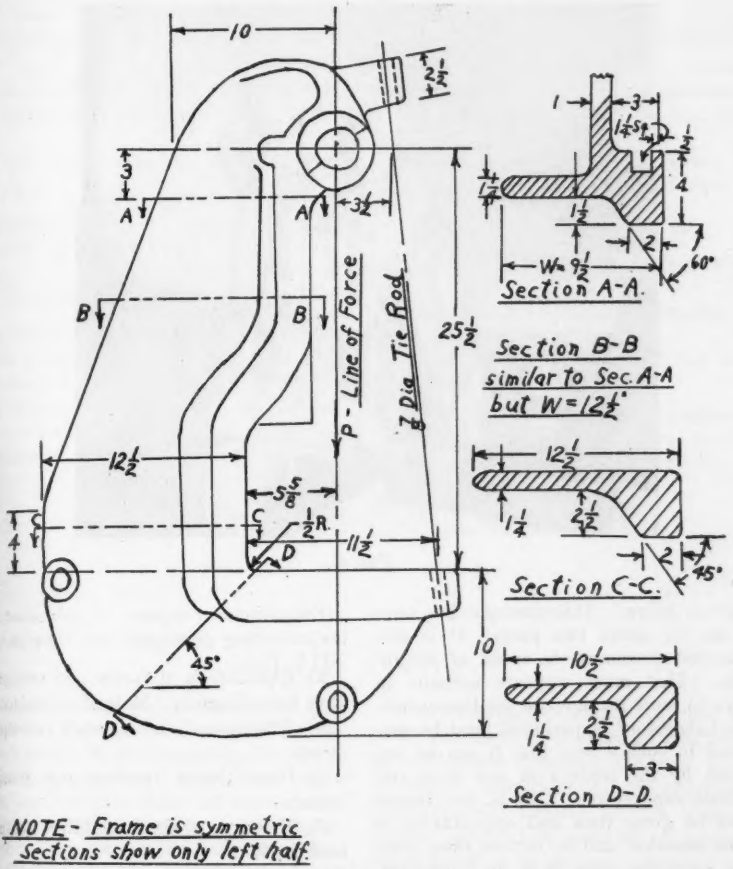

FIG. 4.

employed. The third stage was sometimes developed into highly complex and organized systems, e.g., in some power plant experiments.[4] But neither stage is believed to accomplish the aims of the second stage to which more specifically the name of "Laboratory-Demonstration Experiment" has been given. These aims are of a threefold nature:

1. From the experimental solution the student gets the real feeling of the quantities and methods involved in an otherwise abstract mathematical solution.

2. By comparing the computed and measured values on the basis of the experimental error he can assess for himself the validity of the principles and laws involved in the theory.

3. When dealing with an actual system or machinery he is in the position to account properly for the discrepancies resulting from the idealization of real conditions.

An example of the scheme just described

[4] M. J. Zucrow, *J. of E. E.*, Vol. 38 p. 482.

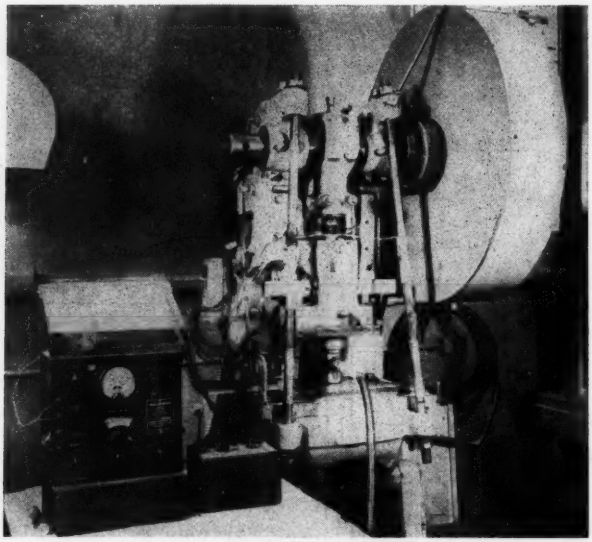

FIG. 5.

is given below. This example has been in use for about two years. It is still somewhat premature to speak of the results. That much appears certain: in order to serve its purpose the Demonstration-Laboratory Experiment must be conceived in such a way that it can be operated by the student at any time and without supervision. That is, the student must be given time and opportunity to make mistakes and to correct them himself, much the same as in his homework.

If it is agreed that the ability to idealize the real conditions forms a part of the engineering *thinking*, and the ability to account for the observed discrepancies a part of the engineering *judgment*, then the proposed scheme accomplishes its purpose.

3. *Example: Stress Analysis of a Punch Press Frame.*

First stage. Problem of strength of materials:

"Computation of Stresses Produced in the Frame Sketched, Figure 1."

Educational purpose: Application of the following principles and theories:

a) Equilibrium of forces and moments. Free body diagram. Method of section.

b) Principle of virtual work (or equivalent).

c) Beam theory (curved and straight beam).

d) Principle of elastic stability (column buckling).

Second Stage. Testing of an idealized system:

"Experimental Determination of Stresses Produced in the Frame, Figures 2 and 3."

Educational purpose: Verification of:

a) Hooke's Law. Establishment of linear relation between applied load and measured strain.

b) Bernouilli's Law. Establishment of linear and hyperbolic strain distribution in the straight and curved parts of the beam.

c) Analytical solution. Determination of the influence of sharp and mild corners.

d) Validity of the theory on the basis of the experimental error. Confidence in the experimental stress analysis.

Third Stage. Testing of actual machinery:

"Determination of Safe Operating Loads in the Punch Press, Figures 4 and 5."

Educational purpose:

a) Idealization of the behavior of the punch press frame for the purpose of a theoretical analysis.

b) Explanation of discrepancies between observed and computed values on the basis of

1) assumed idealizations,
2) assumed mechanical characteristics.

c) Use of Goodman-Johnson (or equivalent) fatigue diagram for the determination of safe operating loads with and without the tie rods.

d) Significance of stress raisers at sharp corners from the point of view of design.

e) Improvement of efficiency by:

1) residual stress (prestressing of tie rods),
2) modification of design (rounding of sharp corners),
3) substitution of a welded for cast frame.

f) Consideration of rigidity (influence of the deformation of the frame on the tolerances of the punching operation).

In the News

Eleven national technical societies and one from Canada have already taken formal action to participate in the international convocation which will celebrate one hundred years of engineering as an organized profession in the United States. This convocation, organized under **Centennial of Engineering**, 1952, is designed to "Provide an opportunity for all engineers to gather to exchange ideas and information of value to one another with no one group taking a place of special prominence."

At a meeting, on October 12, 1950, the incorporators of Centennial of Engineering authorized President Lenox R. Lohr to extend invitations to an additional sixty technical societies in this country, and to appropriate societies of international scope, or of national scope in other countries. The international societies will be invited to hold their annual meetings in Chicago during the Centennial Convocation from September 3 to 13, 1952.

Some Current Practices in Teaching Advanced Composition for Engineers

By MAURICE L. RIDER

State Teachers College, Indiana, Pennsylvania

A limited survey recently completed at The Ohio State University reveals a variety of facts about current practices in teaching English composition for advanced students in engineering.[1] The survey was made by sending questionnaires to thirty-five leading technical schools and colleges of engineering throughout the United States. Of those institutions responding to the questionnaire, twenty-one offered courses in advanced composition for engineers.[2] The facts reported by those twenty-one institutions are here summarized for what significance they may have for teachers of advanced composition in other technical schools and colleges of engineering.

The administrative requirements reported for advanced-composition courses show considerable variation. Quarter hours of credit offered range from two to six, with a minimum of one hour of recitation each week for eighteen weeks to a maximum of three hours of recitation each week for twenty weeks. One course devotes no time to student-teacher conferences, but others allow from one-half hour to three hours of conference time per quarter for each student. Medians computed from the data submitted show the following characteristics for a typical course: quarter hours of credit, 3; clock-hours of recitation, 43; duration of the course in weeks, 16; and average amount of conference time devoted to each student, 2 hours.

Responses to the questionnaire revealed a total of eleven different objectives for the twenty-one courses. The following recapitulation indicates the number of courses for which each of the objectives was listed: (a) to develop proficiency in the correct use of the fundamentals of English (grammar, spelling, punctuation, etc.), 17 courses; (b) to impart skill in writing technical reports, 14; (c) to teach the correct forms of engineering reports, 13; (d) to foster effective writing, 10; (e) to develop skill in writing business letters, 7; (f) to perfect the student's ability to organize data, 5; (g) to teach library research techniques which culminate in effective reports, 4; (h) to foster the writing of articles acceptable to leading professional and technical magazines, 3; (i) to promote clear thinking, 2; (j) to give students help in their current writing for other departments, 1; and (k) "to encourage the student in widening his mental horizons and gaining proficiency in the expression of ideas outside his immediate professional field," 1. The principal objectives of the twenty-one

[1] The survey appears as part of the author's dissertation, "Advanced Composition for Students in Engineering at The Ohio State University: Evaluation and Proposals," Columbus, 1950.

[2] These schools were Brooklyn Polytechnic, University of Colorado, Georgia Institute of Technology, Illinois Institute of Technology, University of Illinois, Massachusetts Institute of Technology, University of Minnesota, Missouri School of Mines, New York University, University of North Carolina (Raleigh), Oklahoma A. and M., Pennsylvania State College, Princeton, Purdue, Rensselaer Polytechnic, Stanford, Texas A. and M., University of Texas, U. S. Naval Academy, Virginia Polytechnic, and University of Washington.

advanced courses in composition for engineers may be summarized as follows: (1) to teach the student to write correctly and effectively the reports and business letters that may be required of him in his professional career, and (2) to teach him to think clearly and organize his work logically.

Replies to the question on the kinds of written work required indicate a total of nineteen different types of original composition. Twenty courses require the writing of one or more kinds of technical reports and fifteen require business letters. Since these two general types of composition may be further subdivided, they are given separate treatment in Tables 1 and 2. Technical expositions of processes and mechanisms are required by ten courses, and the library research report is required by seven. Five courses require the writing of definitions, and four require abstracts, outlines, and descriptions as well as personal data sheets to accompany letters applying for positions. Three courses afford the student practice in writing technical articles suitable for magazine publication, while the compilation of a bibliography and the writing of editorials and book reviews are each a part of the program in two of the twenty-one courses. Other types of original composition required in but a single course are as follows: advertising copy, formal direction sheets, interpretations of graphs and diagrams, news stories about technical subjects, and occupational analyses of the students' chosen fields.

TABLE 1

TYPES OF BUSINESS LETTERS REQUIRED IN COURSES IN ADVANCED COMPOSITION

Type of letter	Number of courses giving instruction
Application for a position	10
Sales letter	8
Letter of transmittal	7
Response to an inquiry	6
Adjustment letter	5
Letter of inquiry	5
Letter of instruction	4
Letter report	4
Inter-office correspondence	3
Order letter	3
Letter of authorization	2
Collection letter	2
Credit letter	1
Recommendation	1
Letter inviting a speaker	1

Of the fifteen kinds of business letters which were listed for the twenty-one courses, the letter of application for a position is most frequently required. The sales letter, the letter of transmittal, and the letter responding to an inquiry follow the letter of application in order of frequency. The adjustment letter and the letter of inquiry are each required in five courses, and the letter of instruction and the letter report are required in four. Other types of letters and the frequency with which they were listed appear in Table 1.

TABLE 2

TYPES OF TECHNICAL REPORTS REQUIRED IN COURSES IN ADVANCED COMPOSITION

Type of report	Number of courses requiring each type
Progress	8
Descriptive or informative report	6
Examination	4
Analytical	3
Inspection	3
Recommendation	3
Completion	1
Periodic	1

Table 2 lists the eight kinds of technical reports taught in the twenty-one courses in advanced composition. The table was made by disregarding the possibility of duplications in nomenclature and listing the name of each kind of report as it appeared on the questionnaires.

The teaching method which instructors in advanced-composition courses reported most effective is the following five-step

procedure: (1) Student writing in response to a clear, specific assignment, (2) grading of the papers, (3) discussion of classwide errors, (4) student correction and revision of papers, and (5) special help to students with individual difficulties. Seven of the twenty-one instructors who filled out the questionnaire mentioned this method specifically—even to the point, in some instances, of outlining the procedure. Ten teachers mentioned the correction and discussion of student papers, and six said they insisted upon and supervised the student's correction and revision of his papers. Class discussion and study of student and professional models antecedent to student writing are elements of the method which were mentioned by seven teachers. Thus thirty of the forty-two responses on classroom procedures dealt wholly or in part with the inductive method of teaching written composition.

The remaining twelve responses that concerned teaching methods were divided among seven different procedures. Each of the following methods was mentioned by two instructors: (1) The work in English is directly related to the student's professional courses. (2) Arbitrary good forms for letters and reports are dictated by the instructor. (3) Opaque projectors are used to show models of student and professional work to the class. (4) Informal lectures on specific writing problems are presented to the class. Each of the following methods was mentioned by one instructor: (1) Lectures on composition problems are given by other members of the faculty and by prominent industrial leaders. (2) Writing assignments are designed to be done in class. (3) Papers and reports of local and individual character are assigned to prevent plagiarism.

While the number of courses from which the preceding data were assembled is too small to provide a representative pattern, the survey does indicate a few of the commoner practices in teaching advanced composition for engineers. In aim and content the courses are primarily practical; that is, they teach the student how to do the writing he will have to do as a practicing engineer. The engineering report, business letter, professional article, and the abstract are the forms most frequently taught. In addition, attention is generally given to the mechanical and structural requirements basic to all effective writing, and the implication is that a part of this training is remedial. The prevailing teaching method requires the student to examine good models, apply the information to new and practical composition assignments, submit his written material for criticism, and carefully revise his manuscript on the basis of the suggestions he receives.

Beyond these few common elements of purpose, content, and method, advanced courses in technical composition vary widely. Their diversity generally reflects the academic background of which each is an integral part, rather than any fundamental disagreement about the functions of courses in technical writing.

Resolution of Thanks

The American Society for Engineering Education duly assembled at its 58th Annual Meeeting in Seattle, Washington on June 21, 1950 wishes to express its sincere gratitude and appreciation to James S. Thompson for his faithful and untiring efforts as Treasurer of the American Society for Engineering Education during the highly critical period since 1942.

His wise counsel and broad experience have been of inestimable help to the Council, Executive Board, and the entire membership of the Society.

Environmental Engineering Aspects of Nuclear Activities*

By ARTHUR E. GORMAN

Sanitary Engineer, Division of Engineering, Atomic Energy Commission, Washington, D. C.

In any discussion of the technology or even the economic potentialities of a new industry, experience has indicated the importance of giving consideration to the environmental impact of that industry. Such consideration is of particular importance if the industry's operations, its products or its wastes are in any way objectionable to community living or hazardous to public health. Environmental problems of industry are of special interest to sanitary and public health engineers because the public has over the years come to these specialists for advice in matters affecting their environmental interest. The purpose of this paper is to present from the viewpoint of the sanitary engineer, some of the environmental problems in the atomic energy industry, emphasizing particularly the obligation of and opportunity for educators in the engineering profession to participate in helping this new industry to enjoy a healthy growth without encountering some of the needless growing pains that other industries have experienced.

Experience of other Industries

Looking in retrospect over the problems which have been associated with the growth of industry in the United States insofar as its impingement on community life, public health and safety and the economics of the local or regional area of operations were concerned, it is quite clear that many mistakes were made. In the light of previous experiences, many were avoidable, some may have been made in ignorance; still others were made because an industry developed far beyond the most optimistic concept of its founders in its influence in the economic or community life of the immediate area or the nation.

For example, many years ago with the realization that theirs was an industry noxious to community life, the stockyards and packing house interests in Chicago moved to an area beyond the city limits. In the course of events, however, the growth of the city exceeded expectations and soon the stockyards and packing houses were surrounded by residential and commercial developments. As a consequence, a whole series of environmental problems arose to plague the industry and the public. Again in the case of the automotive industry little did its founders realize when the first car was built how profoundly in the years to come the automobile would affect the economic structure of the nation, revolutionizing transportation and setting the stage for such great industries as road building, oil refining and rubber tire manufacture. It is doubful if the pioneers in the automotive industry realized that clean streams in which fish were then abundant, would in the years ahead become grossly contaminated by wastes from the new industry they had started; or that the clean invigorating air over the manufacturing areas would become polluted by objec-

*Presented at Fall Meeting of the Engineering College Administrative Council, American Society for Engineering Education, Kansas City, Missouri, October 28, 1949.

tionable dusts and fumes from theirs and allied industries.

These examples of the environmental aspects and potentialities of a new industry could be multiplied many times. But, they will serve to illustrate the depth, the variety and the types of problems which the sanitary and public health engineers of this country have had to face in working with industry; also to point out to members of this association who are interested in the education of engineers, some of the considerations which need to be weighted in appraising professional opportunities and obligations in the fast growing atomic energy industry.

Atomic Energy Industry Different from other Industries

The atomic energy industry differs in many respects from other industries with which we are familiar; but still in matters of environmental sanitation certain patterns are similar; others are new—even unique. Insofar as this new industry differs from others, educators of personnel for this industry will want to adapt training programs to these needs. It may be helpful to refer to some of the areas in which normal American industries differ from the atomic energy industry in organizational and operating policies involving environmental sanitation and public health.

Most industries are privately-owned and are operated subject to the laws of the state in which they are operated. Their raw materials are diverse and their finished products are widely distributed through established competitive channels; waste products which have value are generally promptly reclaimed and those without value before being released are subject to such treatment as public health officials having jurisdiction require. Specialists in such industries working with public officials have helped to develop techniques and procedures for operating controls affecting the public, and together they have arrived at reasonable agreement as to levels of contamination in wastes from various industries which can be disposed of to nature without creating a nuisance or a public health hazard. Usually wastes from normal industries, even though they may be objectionable or hazardous, are short-lived and their environmental effects can be observed in terms of hours, days or weeks.

In contrast, the atomic energy industry by law is federally controlled; knowledge of its operations are subject to strict security controls; there is no profit motive in its commercial operations; the raw materials such as uranium ores are rare and costly and may be imported from distant places; techniques and procedures in processing are unique; the finished product is highly radioactive as are some of the wastes; and, standards or permissible tolerances of contamination for wastes released to nature vary widely within the industry and are unfamiliar to most outside public officials. There are few state or local regulations governing the disposal of these wastes, especially those that are radioactive. This is because so little is known by outside agencies concerning such wastes; and finally, some of the wastes of this industry may be long-lived and if not handled correctly present problems for both present and future generations.

Problems of Waste Disposal

In view of what is already well known about the atomic energy industry, it is obvious that its products are hazardous and must be handled with intelligence and care. The same is true of its waste products. The Atomic Energy Commission is giving much consideration to this aspect of its operations. The principal hazards arise from the effects of radiation, but some products also have toxic properties. Starting with the mining of raw materials from which fissionable material is obtained, and continuing on until the product is prepared as fuel for nuclear reactors, protection against low levels of radiation can usually be obtained by good industrial housekeeping

as practiced in well-controlled chemical industries. After the fuel materials are bombarded by neutrons the level of radioactivity is increased and from then on exceptional methods must be taken both to protect workers in the industry and to prevent products or wastes from exposing others off-site to hazardous amounts of radiation or to wastes which are toxic. Such precautions are taken and responsibility for this work has fallen on a new group of specialists known in the industry as health physicists. They have been and are doing a good job and deserve much credit for the control measures which have been put into effect.

Problems of environmental sanitation exist in dealing with toxic and radioactive wastes especially when the amounts and levels of activity are high. As with other industries, waste products to be disposed of may be in solid, liquid or gaseous forms. Unfortunately, the problems of disposal in any of these forms are by no means as simple as in other industries. Standard equipment and established methods of treatment are not always usable with radioactive materials, especially those of high energies and long half-lives. For example, equipment used in handling radioactive materials may have to be taken out of service because of the high level of radioactivity it has acquired and not because it has worn out. Ordinary maintenance tanks may require special shielding to protect workers and in the design and installation of equipment special consideration must be given to this aspect of the industry. It is in developing new solutions to these problems that chemical and sanitary engineers are needed in the atomic energy industry whose training in nuclear physics is adequate to permit them to keep abreast of the research and developmental work carried out by the nuclear physicists. The new products or methods developed in research must ultimately be engineered for production units and these should include auxiliaries for treatment and disposal of wastes. This is true whether we are dealing with applications of atomic energy for civilian or military applications.

Initially, the principal objective of the atomic energy industry in this country was to develop a military weapon; and to a large extent its energies are still being directed toward military objectives. During the war, naturally, production had a priority over considerations of waste disposal, although these were not neglected. An appraisal of waste disposal problems in the post-war period has shown, however, the need of improved methods of treating wastes, and as the atomic energy program expands, disposal facilities are being developed and installed. Already today, industrial plants in many states assist in processing nuclear fuels for the atomic energy industry, and radioactive materials are shipped to and from widely scattered production areas. Radioisotopes are being used in research institutions in about 40 states.

The Atomic energy industry is not as fully integrated into the American community and economic system as are most other industries. The original plants and laboratories at Oak Ridge, Tennessee; Hanford, Washington; and Los Alamos, New Mexico were specifically located in isolated areas and its employees were housed in federally controlled villages. In matters of environmental sanitation this situation has its obvious advantages and disadvantages. Isolation of production plants and laboratories is desirable from the standpoint of security and certain potential environmental hazards especially in disposal of wastes. Isolation of research areas has the disadvantage of distance from institutions cooperating on related research and readily available reservoirs of trained technicians and other workers. As a latecomer in the American industrial field, the atomic energy industry faces the problem of adjusting its operations to those of an organized economy and established ways of community life.

It is of fundamental importance that the site on which a plant for production of nuclear products be carefully selected

from the point of view of such environmental factors as: (1) distance from other industries or communities; (2) availability of an adequate source of water supply; (3) effect of products or wastes if accidentally released on sources of ground or surface water supplies; (4) meteorologic conditions in the area and general vicinity; (5) topography and geology of area in relation to security and structural factors; (6) availability of housing and community facilities; (7) transportation.

Cooperation with other Public Agencies

One of the important steps found in integrating this new industry into the national pattern has been in calling upon other public agencies for assistance in the fields of their special interests, proficiency and responsibility. This involves indoctrination of their experts in operations of the atomic energy industry and in turn getting from them judgments arising from experience in dealing with many other industries over the years. In matters of environmental sanitation such long-established federal agencies as the Geological Survey, the Public Health Service, the Bureau of Mines and the Weather Bureau have been most helpful. The Geological Survey has investigated geology at and in the vicinity of several production and research areas under A.E.C. control in connection with availability of water supply, the effect of disposal of wastes on water resources; and the suitability of soils for disposal of wastes. The Public Health Service with long experience in treatment and disposal of domestic and industrial wastes and pollution of waterways has assigned experts to assist in research in disposal of radioactive and toxic wastes peculiar to the atomic energy industry and in research in methods of removing radioactive decontamination from water. The Weather Bureau has cooperated in numerous areas in study of meteorological conditions affecting operations at production and research plants where the decontamination and release of radioactive gaseous effluents is or may be a matter of concern. In addition to cooperating with these federal agencies in resolving problems of environmental sanitation the prime production and research contractors of the Atomic Energy Commission have and are carrying out important research on waste disposal methods at their various areas of operation. Furthermore, contracts have been made with research institutions to do similar work. Of special interest to sanitary engineers is research being carried on in waste disposal and decontamination of radioactive water, being carried out at the Oak Ridge National Laboratory, Los Alamos, and by the Sanitary Engineering Divisions of the Massachusetts Institute of Technology, New York University and The Johns Hopkins University.

Certain state agencies have also cooperated with the A.E.C. in problems of environmental sanitation. Their participation has been less, not because their assistance is not needed, but principally because there have not been available in these agencies personnel trained in those aspects of nuclear physics which are essential to an understanding of the industry's problems in relation to local responsibilities.

Need of Training Public Officials

To date supervision and control over production, use, transportation and disposal of radioactive materials and wastes have been carried out within the industry with little attention by outside public agencies which normally have responsibility for industrial operations in areas of their jurisdiction. This situation which grew out of wartime security conditions is gradually being adjusted but has continued because among the staff members of such agencies knowledge of nuclear physics and problems of this industry which would be required to exercise normal governmental controls, is lacking. Since it is quite obvious that the atomic energy industry is here to stay and that

it will be widely developed to serve our citizens, it is important that knowledge concerning this industry should be better understood by all, especially those having a direct interest or concern. The Atomic Energy Commission is seeking to broaden the base of knowledge concerning this industry and in this effort educators of engineers can be of great service. The acute shortage of research workers trained in nuclear physics, techniques, instrumentation and interpretation of results has been relieved to some extent by training courses sponsored by the A.E.C. and by some of the military agencies. But, the number of trainees in the engineering field is limited and the industry will continue to be embarrassed in a healthy expansion program until education and training of workers both within and without the industry can be expanded. In particular, there is a need of educating and training public officials who have a responsibility for public health and safety. It is timely to point out that these officials and those operating public utility systems such as water and sewage works also occupy strategic positions in public service.

It is highly desirable if plans for the expansion of the atomic energy industry are to go forward that in matters of environmental sanitation involving this industry, federal, state and local officials be given training in nuclear physics. It is in this connection that the directors of educational institutions can be most helpful. A logical attack on this problem calls for immediate action on two fronts:

1. Training of the young engineer in the making;
2. Training of experienced engineers already carrying public responsibilities and qualified to help the atomic energy industry, but lacking knowledge in nuclear physics and the special problems of the industry.

If we agree that atomic energy has great potentialities for service in this world then the educator of young engineers in all branches of the profession should be given well-balanced instruction in nuclear physics and its applications. In schools offering degrees in sanitary and public health engineering such instruction should be especially thorough. The training should give emphasis to the environment aspects of atomic energy operations particularly in relation to hazards involved in transporting and handling of materials, and in disposal of wastes of all kinds. It should include use of instruments and interpretation of data. Education and training of engineering graduates along these lines will develop in the future a wider understanding of the problems of the atomic energy industry; will permit better balance within the industry of responsibility carried by engineers in the fields of their specialty and in the long run, will permit the industry to become more effectively integrated as a normal unit of our national life instead of an awesome oddity little understood and much discussed.

The training of the older graduate engineers experienced in public service, such as sanitary engineers, geologists, industrial hygienists, water and sewage works specialists and others, in nuclear physics and its applications in research and production in the atomic energy industry presents a complicated problem to engineering educators. It is, however, an obligation which should carefully be appraised and I hope promptly accepted by the American Society for Engineering Education if this industry is to enjoy a healthy growth. Looking at this problem from the standpoint of attaining a firm civilian defense position, action toward initiating training programs should be started at once.

The experienced engineers in the various professional classifications previously referred to have much to offer the atomic energy industry and, where their services have been called upon, this has been amply demonstrated. A great deal of research and development work in water supply and purification, use of water for heat exchange, collection, storage, treatment and disposal of radioactive wastes,

and in the development of special equipment is needed and this demand will continue as the industry grows. Work in this direction is being retarded because of shortage of specialists in these fields who have knowledge of nuclear physics.

It is the writer's opinion that a combined effort by the principal federal public agencies concerned and the directors of engineering education in American colleges and universities, is needed to develop adequate training of these older engineers in order that their usefulness in their jobs and to the atomic energy industry may be fully realized. Some negotiations, looking forward to special training of sanitary and public health engineers, have already been entered into with the National Research Council through its Subcommittee on Sanitary Engineering and Environmental Sanitation. In a three-way cooperative program, as referred to, the public agencies after evaluating their interests in and possibilities for service to the atomic energy industry could select key men for training. In turn, the staff of the Atomic Energy Commission, after being advised of the interests and service possibilities of these outside agencies, could suggest the types of problems in the industry in which the trainee could help most and arrange to establish avenues of approach within the industry which would bring the trainee into realistic contact with these problems. Consultation between the industry, the public agencies and educators of engineers could develop the type of instruction and length of training which should precede, accompany, or follow the trainee's contacts with the industry's operational problems. Through a well-coordinated program of this kind small groups of experienced engineers could be assigned to various A.E.C. areas or educational institutions for practical and theoretical training.

It is understandable that educational institutions look with disfavor on certain types of "short course" training, especially in the basic sciences. But the problem which faces the atomic energy industry in public health and environmental sanitation today are so unique that they warrant special consideration. In conclusion, I am sure your society will want to help the industry through this transition period when the experienced public health engineer, without knowledge of nuclear physics, will be called upon to serve until the young engineer, who is being trained in the fundamental principles on which the atomic energy industry rests, can attain the experience which will permit him to pull a strong oar in meeting the many environmental problems which lie ahead in the growth of this new and important industry.

THE COOPERATIVE DIVISION

will hold a

Mid-Winter Meeting

at

The University of Florida

Gainesville, Fla. ***January 9 and 10, 1951***

Surveying Instruction in the Civil Engineering Curriculum*

By HERMAN J. SHEA

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Probably no other subject in the Civil Engineering curriculum is open to so wide a latitude in continuity, course content, emphasis and time allotment as is Surveying. One of the factors leading to this variation is whether the field work is given during a regular semester, on or near the campus during the summer, or at a summer surveying camp. Another influence on the surveying program is whether field work is taught together with theory or subsequent thereto.

With these deviations in mind it is both impossible and undesirable to present a singular solution for the design of a surveying program. Rather, any treatment must take the form of a description of instructional method adopted by one institution. No claim is advanced that our approach is perfect, but it is the product of much thought and serious consideration.

Certainly a periodic review of course content is both wise and necessary. To keep abreast of recent developments and to include them in the curriculum with proper emphasis should be the aim of every surveying instructor. However, it is patent that new material is being constantly introduced into the Civil Engineering curriculum. Thus time and subject allotments within the surveying program are complicated by the twin pressures of new material and decreased time. To design carefully under such conditions calls for careful judgment leading to the best and wisest use of the actual time available.

A major precept which governs the arrangement of our surveying program at M.I.T. is that students, when in normal succession, will have completed all their surveying subjects by the end of their sophomore year. It is our feeling that by so doing, the student is presented with a definite advantage when seeking summertime employment. Not only will their chances for sub-engineering positions be heightened, but the student will be better able to benefit from such practical experiences.

Since the first-year program at M.I.T. is identical for all students irrespective of course selection, one of our curriculum requirements for surveying is that all subjects be scheduled between the end of the freshman year and the end of the sophomore year.

Summer Surveying Camp

Students are introduced to surveying through attendance at the Civil Engineering Summer Surveying Camp at East Machias, Maine. It is presumed that these students have had no descriptive or theoretical course in Surveying. We are then committed to a program of instruction combining description, theory and practice. In my personal experience at M.I.T., I have had the opportunity to compare those students who have taken a theory course before attendance with those who have had none. It has been my personal finding that the latter group adjusts itself quickly,

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has forgotten nothing, for there is nothing to forget, and in the course of a relatively short time, finds itself in the same position as those with previous instruction. A class room description of an engineer's transit followed by an interval of four to eight months before using the instrument impresses me as a waste of time. Terms hazily understood and unreinforced by actual usage are not apt to stay in the student's mind over long periods of time.

Our initial work at Camp is devoted to training the student in the handling of the various instruments and practice in elementary surveying methods. We aim, at the end of two practice rounds, to develop the student to the point where he may, counselled by the instructor, participate in the survey of an area and concentrate his attention on the problem at hand without being distracted by major questions of technique.

Since, to my mind, the first steps in a fieldwork subject are important toward setting the pace of the course, I should like to describe in some detail the work of the first few days. The first morning at Camp is divided into three lectures—lectures on a grouping which I like to think of as the optical instruments of surveying; the plane table and alidade, the engineer's transit and the engineer's level. Our first round of fieldwork is devoted to one day's practice in each of the above instruments.

With the plane table and alidade, the student carries out the principles of intersection, resection and the three-point problem using range poles on a comparatively level stretch of land. Thus the student is able to see, at one glance, the translation of these points onto his plane table sheet. To avert the impression that these methods are adapted to ranges of 300–400 feet, the operations are repeated on a preplotted plane table sheet to a scale of 1/20,000 using control stations roughly two miles away. During this work, the student is naturally becoming acquainted with the handling of a plane table board and tripod, orientation of a map sheet, and manipulation of the telescopic alidade.

The remainder of the plane table exercise consists of observing a plane table traverse having about ten sides. This project provides the student with a graphic introduction into the general subject of traverses. Likewise he is able during the first time he runs a traverse to have a visual record of his error of closure—a point that should start him thinking about precision. A third novel feature, to the student, is the reading of distances by the stadia method.

The student's work with the engineer's transit starts with his setting a transit over a point and reading single angles on distant targets. These observations are conditioned, naturally, by the requirement that the sum of the angles totals 360°. To point out the advantage of checking each angle as it is measured and to show how superior precision may be obtained, the student immediately reobserves the same angles by the method of repeating each angle three times. If the student is required to maintain a check between his first repetition and the average from his third reading, the certainty with which the sum of the angles will depart by only small values from the theoretical amount should serve to show him the value of observing local checks whenever possible.

The exercise devoted to the engineer's level consists of running levels between established benchmarks. These runs are designed to be short enough to permit each student to observe a known difference of elevation. Thus a check of his effectiveness is immediately available.

Second Group of Exercises

Our second round of preliminary exercises is prefaced by a series of three lectures on contours, principles of stadia and taping. As before, these discussions are followed by one-day exercises in the location of contours by use of the plane table, a day on observation of a stadia traverse and a third day on taping.

In the first exercise, that of contour determination by use of the plane table, the student spends the first half-day chasing in contours by means of a level telescope and the second half-day taking vertical angle stadia shots and interpolating the contours. Thus the student should see the topography grow on his plane table sheet and he should early acquire a feeling for contours.

The stadia traverse project provides the student with his most complex instrument technique and party organization to date. Our traverses consist of 12-sided figures, each starting point near a benchmark and provided with a variety of sights. By carrying elevations and azimuths, checking foresights by appropriate backsights, the student hopes to insure a reasonable closure. I can well attest to the student's feeling of concern when the closing point is reached.

Taping, as we well know, is simple in theory and difficult of practice. The student starts by taping a line about 800 feet long, forward and backward, by horizontal taping. We require an apparent agreement of one part in 10,000 between the two measures. Much care is taken to impress upon the student that this agreement is apparent only and that temperature effects and erroneous length of tape undoubtedly influence his result in far greater amount than his agreement. As a prelude to vertical angle taping, the student observes by horizontal taping the distance between two points at the top and bottom of a steep banking. He is then more than ready for vertical angle taping. This latter method shows the student an efficient means of securing distance measurements where the difference of elevation is great.

We place much importance on these preliminary exercises for we feel that a student properly grounded during this series is ready for large scale practical problems. It is, of course, true that he should be constantly improving the quality of his workmanship, but the introductory phase should be over.

In groups of six, the students are assigned to instructors to perform the complete mapping of an area approximately 1000 feet square. A control traverse is run to a specified precision of one part in 5000. This traverse is laid out to serve most efficiently as control for the final map. Vertical control is next established with temporary benchmarks near each traverse station. After satisfactory sun azimuths are obtained and the traverse computed, a plane table sheet is prepared. This manuscript map serves as a record for topography taken with the plane table and the transit stadia information is plotted thereon. We attempt to secure about one-half the topographic information directly through the use of the plane table and the other half by transit stadia.

Each student is required to prepare a finished map of his area. Much as we may admire maps drawn in colors on heavy white paper, the fact must be faced that virtually no engineering office would allow the time necessary to prepare such artistic triumphs. We therefore specify that the student's effort be done on tracing cloth with ink. The map must not only be accurate, carefully drawn and pleasing from an engineering standpoint, but it must be efficiently executed.

In the first portion of our work at the Summer Surveying Camp, there are naturally many items of instruction which are properly part of the work. I should like to mention specifically two particular subjects. One is the observing of stars for time, latitude and azimuth. While the former two observations are relatively infrequent in engineering practice, the student who is able to handle his instrument in the dark with the aid of unsatisfactory illumination is well along the way toward mastery of his subject. Of course, observations on Polaris for azimuth have has a distinct bearing on the practical execution of surveys.

The satisfactory teaching of instrument adjustments is, to my mind, an important feature of surveying instruc-

tion. Our practice is to require the student to test the instruments (transit, level and alidade) which he had been using in the field and to report on their condition of adjustment. By this means he becomes familiar with the errors. He is then handed an older transit and level purposely put out of adjustment and is told to come back with the instruments in perfect working order. By providing the student with older instruments, the damage is somewhat confined.

Advanced Program

The second portion of the Surveying Camp (three weeks out of a total of seven) is allotted in equal parts to Route Surveying Fieldwork and to Advanced Surveying Fieldwork. In the former, the student meets for the first time that broad division of Surveying which we might call layout work. Previously he has been engaged in analytical measurements on quantities already in place. That the staking out of structures is important and a wide field of practical surveying, no one will deny. Why not, therefore, lay stress on this at an earlier date and to greater extent? Our feeling is that the student must first have a thorough background in the handling of his instruments and in the methods of surveying to permit a concentration of attention on the efficient solution of his layout problem.

Regardless of the project, whether it be a highway relocation, an earthwork estimate, a column or building location, an important point that should be kept in mind by the student is that construction survey points have a high degree of mortality. We feel that adequate instruction must be given to working along offset lines and that efficient references well outside the construction area be included in the survey.

One noteworthy feature of this type of survey is that the scope of the project should be, on the one hand, of sufficient size to stimulate a sense of accomplishment, and on the other, limited enough that the completed survey be easily visualized.

In Advanced Surveying Fieldwork our purpose is to introduce the student to some of the more precise methods of surveying. Briefly, the projects covered are: angles with a repeating instrument, directions with a micrometer microscope theodolite, base line measurement with a 50-meter tape and stakes, precise traverse with a 100-foot steel tape and taping bucks, and precise levels with a tilting dumpy level. Within the scope of this course, stream volume measurements and soundings are also covered.

While the major emphasis of our Camp curriculum is on fieldwork, theoretical discussions are held whenever necessary to an adequate understanding of the problem at hand. We find that we are able to cover the entire subject matter of such an elementary book as "Breed's Surveying" as well as numerous excursions into higher surveying.

Upon his return to the Institute, the Civil Engineering student registers for Advanced Surveying in the fall semester and for Route and Construction Surveys in the spring. In both of these courses, the work at the Summer Surveying Camp is continued and amplified. Wherever possible, fieldwork data taken at the Camp serve as problem material.

It is with the former course—Advanced Surveying—that I am particularly concerned and I should like to present some of the features of that course. In the recitation part of this course, engineering astronomy, base line measurements, triangulation, and precise leveling are covered in some detail. Likewise, instruction in State-wide rectangular coordinate systems is included.

Astronomy

The teaching of Engineering Astronomy is a case in point where the decreased time allotment has had a major impact. To present in a limited time the full scope of Practical Astronomy to a student is well nigh impossible. Such a

course might well be a full term's work. We have adopted the compromise of grounding the student carefully in the basic definitions and then develop the Greenwich Hour Angle system as a practical approach for problems wherein time enters. Such a development has the virtue of simplicity and may be comprised in a much shorter time.

An adequate coverage of the Lambert Conformal Conic and the transverse Mercator projections as adapted to State-wide rectangular coordinates is, to my way of thinking, extremely important. We develop sufficient theoretical background for an adequate understanding of these systems, but concentrate considerable attention in showing the student how such layouts are adaptable to routine surveys.

The drafting room section of this course is devoted in equal portions to the solution of engineering problems by use of contour maps and to photogrammetry. In the former, an attempt is made to introduce the student to the various fields of Civil Engineering through assigned projects. Thus Hydraulic Engineering is met by way of the determination of a watershed area and the volume of the resulting impoundment; Sanitary Engineering by the design of a sewer system for a land development; Transportation Engineering by grading considerations for a highway and an airport; and Structural Engineering through a bridge triangulation problem. True the projects are both simplified and without the complex details which are properly part of a complete design. But there is much to show a student and such an early introduction, we feel, is not amiss.

Concerning the teaching of Photogrammetry to Civil Engineering students, I have some definite ideas. As a generalization, I feel that instruction in this subject is most certainly part of a Civil Engineering student's training in Surveying. But I do feel that the guiding thought should be to show the students what use they, as potential engineers, can make of aerial photographs with only limited equipment; and secondly to point out what specialized companies in this field can do for them. A listing of our projects in photogrammetry should give some idea of what I feel belongs in the former category. These are:

1. Preparation of a flight map
2. Preparation of an index map
3. Geometry of a vertical aerial photograph-displacement due to relief and tilt
4. Radial line plot—two flight lines, 10 prints of an area in the vicinity of our Summer Surveying Camp where adequate control is available
5. Complete preparation of a planimetric map based on Project 4—detail transferred by use of vertical reflecting projectors
6. Scale check problem, vertical print—coordinates taken from a print, altitude of exposure found, and length of a second line determined (the latter measure is compared with a known length giving the student an indication of the precision of the process)
7. Tilt of an aerial photograph from scale check lines
8. Height of an object, such as a stack, from a stereo-pair
9. Preparation of a stereo-pair for contouring
10. Examination of stereo-pairs for detailed information

The above listing omits the various instruments which are appropriate to the projects. Such equipment as lens and mirror stereoscopes, vertical reflecting projectors, height finders and stereo-comparagraphs should be available. There is, of course, considerable lecture work necessary to the introduction of the above projects.

In developing this paper, the thought has occurred to me at this stage that I have concentrated on a design for what (it is my fond hope) should be a technical excellence on the part of the stu-

dent. Yet there is much more to the training of a student in Surveying. Throughout this subject there is an excellent opportunity to inculcate professional and ethical responsibilities. Since the result of a survey is highly flavored by the character of the parties concerned, there is no readily applied criterion to judge the accuracy or completeness of the product. Those standards which we are in a position to apply must be both technically and ethically sound. Redesign of our courses has been necessary, but any arrangement must include the facts and ideals of life. For surveying, these include education leading to a competent workman who does a professional piece of business.

ECPD News

Better engineers, fitted for the increasing tempo of technical progress and developed through more efficient use of the first five years following graduation, is the objective of a long-term program announced by the Engineers' Council for Professional Development. The study is the result of more than 15 years of work on the part of the E.C.P.D. Committee on Professional Training under the chairmanship of A. C. Montieth, Vice President of Westinghouse Electric and Manufacturing Company. Essentially it is a guide which assumes that a young man with potential, and whom the report characterizes as "the most important person in this country today, is willing to contribute heavily in time and effort toward his own development. The engineers picked the five years following graduation as the most important in a professional man's life, since he is then on his own and if the period "can be filled with a helpful program, the further progress of developing the engineer will be a natural evaluation." The committee felt that if, within the first five years, the young engineer did not organize his thinking and see through the complexities of modern industrial life, he would not be able, eventually, to assume leadership.

The E.C.P.D. program is divided into five parts. The first covers the orientation and training of engineering personnel by employers. The committee studied the training programs of 54 companies and reviewed the published information about programs of about 80 other industrial firms. The study showed that the cost of industrial training was minor, and that results after the first year usually held enough promise to convince management that further development and further training were wise. The committee characterizes industrial training as "the first and best opportunity to start the young engineering graduate on a professional development program."

The second part outlines plans for cooperation in industrial and engineering schools for the continued education of the graduate engineer. "Industrial management must do more than provide orientation and specialized treatment," the committee report states, "it must be concerned with the education of the whole man and employers in industry and government, in cooperation with the colleges, have the responsibility of providing continued education for the engineering graduate." A way of meeting this responsibility was suggested by a subcommittee which surveyed various study programs and found that out of 50 industrial centers, some 23 offered evening study opportunities for engineers through local colleges. For those communities that have no local engineering school, they recommended that local engineering societies encourage industry and the state universities to establish extension centers; that the engineering societies sponsor refresher courses, round-table discussions, and lecture series in specialized fields of interest to the community.

The third section of the report deals

(*Continued on 191*)

Report of ASEE Mechanics Division Summer School, Iowa State College

More than one hundred interested teachers of Mechanics attended the five day Summer School on Dynamic Teaching of Mechanics held at Iowa State College, September 11–15, 1950. Thirty-nine institutions were represented in the registration list.

The first day was devoted to background material with an examination of the learning process by Dean Kerekes, a discussion of the historical development of mechanics by Dean Hollister and a consideration of the prerequisite material in mathematics and physics by Dr. Cell. Each of the following days was devoted to a consideration of the course content and techniques of effective teaching of one of the four subjects, Statics, Dynamics, Mechanics of Materials, and Fluid Mechanics. In one evening session Dr. Grinter presented results of some experiments in teaching methods for non-average students and Professor Muhlenbruch outlined the use of teaching aids in presenting the work in mechanics. Slides of a number of teaching aids and a movie on a presentation of mechanics were shown. Examination techniques was the subject of another evening meeting, at which time Professor Howe gave a survey of types of examinations and methods of grading.

One feature of the Summer School which received considerable favorable comment was the amount of time left available for discussion. Approximately three hours were allocated to each session with one, or in a few cases two, scheduled speakers. At least an hour was available for general discussion of each of the topics, thereby giving all who were interested an opportunity to participate. Many excellent discussions were presented from the floor.

At the closing dinner on Friday evening Dr. Warren E. Wilson, President of the South Dakota School of Mines gave an excellent address on "Mechanics—The Foundation of Philosophy." Inspection trips were scheduled to several of the Laboratories and in addition the Synchroton and College TV Station were visited by interested groups.

Condensations of papers and discussions are scheduled to appear in the issues of the Mechanics Division Bulletin during the forthcoming year.

ECPD News

(*Continued from 190*)

with the relationship of the neophyte engineer with his community. The committee stated that the engineer has a certain responsibility to his community since the public has "made a great investment in him through the taxes and endowment funds provided for higher education. Too many young engineers, particularly in the last few years, have been concerned with the 'rights and privileges' rather than with the obligations and responsibilities which the pursuit of the profession entails," the report stated.

For guidance in integrating the engineer with the community, the committee surveyed present practices and found no cohesive program yet developed. To overcome this, the group said that the responsibility rests first with local sections of engineering societies; second with

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THE T-SQUARE PAGE

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Mid-Winter Drawing Division Program—ASEE
Texas A. & M. College

COLLEGE STATION, TEXAS

January 18, 19, and 20, 1951

The Agricultural and Mechanical College of Texas (Texas A and M) is celebrating its 75th Anniversary during 1950–51. The Drawing Division was invited to hold its Mid-Winter Meeting at College Station, Texas, during the annual meeting in Seattle. The Executive Committee accepted the offer and fixed the dates of January 18, 19, and 20, 1951. The tentative program includes:

(All Meetings in Memorial Student Center)

Thursday, January 18, 1951

7:00 A.M.–6:00 P.M.	Inspection trip to Humble Oil and Refining Company (Gasoline refinery, butadiene plant, and rubber plant); new ship channel tunnel; San Jacinto Monument; Battleship Texas; National Biscuit Company; new $100,000,000 Houston Medical Center; etc. Meet in lobby at 6:45 A.M.
7:30–10:00 P.M.	Dinner Meeting of the Executive Committee. Meet in lobby at 7:15 P.M.

Friday, January 19, 1951

8:00–8:30 A.M.	Registration
8:30–10:00 A.M.	Open House—Engineering Drawing Department (Anchor Hall).
10:00–12:00 Noon	Conducted tours of Texas A and M.
12:15–1:15 P.M.	Drawing Division Luncheon. Greetings from the College, President M. T. Harrington. Response, Professor Ralph S. Paffenbarger, Chairman, Drawing Division of ASEE.
1:30 P.M.	Division Program "The Design and Development of the Agricultural Airplane"—Fred I. Welck, Research Engineer and Distinguished Professor of Aeronautical Engineering, Texas A. & M. College. "Drawings for Jigs and Fixtures"—Homer Briggs, Reed Roller Bit Company, Houston, Texas. "Drafting Problems Encountered in Structural Steel Fabrication"—R. M. Sherman, Central Texas Iron Works, Waco, Texas.
6:30 P.M.	Dinner Meeting Music—Bryan High School Acapella Choir. Humorous—"The Future We're Headed For It," Cayce Moore, The Nation's Most Famous Barber. Speaker—"The Future of Plastics," Elgin B. Robertson, Texas Professional Engineer.

Saturday, January 20, 1951

8:00 A.M.	Descriptive Geometry Film—Evaluating Committee: 1. Professor J. H. Porsch, Chairman Engineering Drawing and Descriptive Geometry, Purdue University. 2. Professor C. C. Perryman, Engineering Drawing Department, Texas Technological College. "Technical Drawing Curriculum Leading to a Bachelor of Science Degree"—Professor H. C. Spencer, Director, Technical Drawing Department, Illinois Institute of Technology. Discussion: Professor A. S. Levens, Division of Engineering Design, University of California. "A Re-examination of the Methods of Teaching Basic Drawing"—Professor H. L. Henry, Mechanical Engineering Department, Louisiana Polytechnic Institute. Discussion: 1. Professor R. M. Coleman, Department of Engineering, Texas Western College. 2. Professor R. P. Hoelscher, Head Department of General Engineering Drawing, University of Illinois.

A ladies program is being planned.

This is the program as of early October, 1950, when copy was submitted to the T-Square Page. The final program with blanks for hotel accommodations for advanced registration will be mailed members of the Drawing Division in December, 1950.

College Station is on State Highway No. 6, half way between Waco and Houston.

Reservations are to be returned to Professor B. F. K. Mullins, Engineering Drawing Department. Texas A & M College, College Station, Texas.

New Members

ANDERSON, CLIFTON A., Professor of Industrial Engineering, Pennsylvania State College, State College, Pa. E. B. Stavely, E. Baldwin.

BENTLEY, MARK W., Instructor in Engineering Drawing, Mississippi State College, State College, Miss. H. P. Neal, C. P. Marion, Jr.

BEROZA, PAUL P., Assistant Professor of Electrical Engineering, University of Southern California, Los Angeles, Calif. G. T. Harness, R. C. Lewis.

BIEGEL, JOHN E., Instructor in Industrial Engineering, University of Arkansas, Fayetteville, Arkansas. H. W. Risteen, G. F. Branigan.

BLANKLEY, ROY EARL, Instructor in Engineering Industrial Arts, University of New Mexico, Albuquerque, N. Mex. M. C. May, R. J. Foss.

BRADBURY, DONALD, Associate Professor of Mechanical Engineering, Rhode Island State College, West Kingston, R. I. T. S. Crawford, F. W. Hoye.

BRAND, RONALD S., Assistant Professor of Mechanical Engineering, University of Connecticut, Storrs, Conn. F. L. Castleman, C. H. Coogan.

BROCKENBROUGH, THOMAS W., Assistant Professor of Civil Engineering, Virginia Polytechnic Institute, Blacksburg, Va. E. B. Norris, F. C. Morris.

BROUGHTON, DEAN C., Assistant Professor of Mechanical Engineering, Syracuse University, Syracuse, N. Y. J. S. Rising, J. A. King.

COVAULT, DONALD O., Instructor of Civil Engineering, University of Colorado, Boulder, Colorado. W. Raeder, H. H. Kelly.

ECKERT, KERMIT, Instructor in Electrical Engineering, California State Polytechnic College, San Luis Obispo, Calif. E. C. Glover, C. E. Knott.

EAGER, MARCY, Assistant Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. E. Tucker, K. L. Wildes.

FAIRBANKS, GUSTAVE E., Associate Professor of Agricultural Engineering, Kansas State College, Manhattan, Kansas. F. C. Fenton, L. E. Conrad.

FEAD, JOHN W. N., Assistant Professor of Civil Engineering, South Dakota State College, Brookings, S. D. E. E. Johnson, R. D. Anderson.

FRANCE, EDWARD L., Assistant Professor and Head, Automotive Department, Utah State Agricultural College, Logan, Utah. F. Preator, J. E. Christiansen.

FRANKEL, JACOB P., Assistant Professor of Engineering, University of California at Los Angeles, Los Angeles, Calif. W. L. Orr, C. M. Duke.

GATES, NEWELL L., Director, Technical Institute, Franklin University, Columbus, Ohio. J. T. Faig, D. E. Deyo.

GISSER, DAVID G., Instructor in Electrical Engineering, Rensselaer Polytechnic Institute, Albany, N. Y. W. C. Stoker, L. P. Winsor.

GREAVES, MELVIN J., Associate Professor of Civil Engineering, Utah State Agricultural College, Logan, Utah. J. E. Christiansen, H. R. Kepner.

GROVER, KINGMAN N., Instructor in Humanities. The Cooper Union, New York, N. Y. W. B. Embler, R. W. Cumberland.

HAAS, VINTON, B., JR., Assistant Professor of Electrical Engineering, University of Connecticut, Storrs, Conn. K. L. Wildes, G. Timoshenko.

HANNA, WILLIAM J., Assistant Professor of Electrical Engineering, University of Colorado, Boulder, Colo. G. Dobbins, H. H. Kelly.

HAUSMAN, PAUL G., Professor and Chairman, Engineering Shop Practice Department, University of Kansas, Lawrence, Kans. K. E. Rose, A. S. Palmerlee.

HENDRICKS, IRA K., Director of Libraries, Utah State Agricultural College, Logan, Utah. F. M. Dawson, A. B. Bronwell.

HENNICK, DONALD CUMMINS, Assistant Professor of Mechanical Engineering, University of Maryland, College Park, Md. S. S. Steinberg, R. B. Allen.

HEWITT, GEORGE S., Associate Professor of Electrical Engineering, University of Arkansas, Fayetteville, Ark. D. D. Lingelbach, G. H. Scott.

HOBSON, MERK, Assistant Professor of Chemical Engineering, University of Nebraska, Lincoln, Neb. H. T. Bates, J. H. Weber.

HOLLISTER, CLAY H., Professor and Head, Engineering Administration, Case Institute of Technology, Cleveland, Ohio. O. M. Stone, H. R. Young.

ISRAELSEN, ORSON W., Professor of Irrigation and Drainage, Utah State Agricultural College, Logan, Utah. F. M. Dawson, A. B. Bronwell.

KEMP, A. B., Instructor in Welding, Utah State Agricultural College, Logan, Utah. J. E. Christiansen, F. Preator.

KLUTE, DANIEL O., Assistant Professor of Mechanical Engineering, University of California, Berkeley, Calif. A. S. Levens, J. L. Meriam.

KOLINER, RALPH, Associate Professor of Civil Engineering, University of Pennsylvania (Towne School), Philadelphia, Pa. E. F. Stover, D. T. Harroun.

KRAVETZ, ADAM J., Lecturer in Electrical Engineering, University of Toronto, Toronto, Ontario, Canada. G. F. Tracy, L. S. Lauchland.

KULESA, WALTER E., College and University Relations, General Motors Corporation, New York, N. Y. R. F. Moore, K. A. Meade.

LARSSON, ROBERT D., Assistant Professor of Mathematics, Clarkson College, Potsdam, N. Y. W. J. Farrisee, E. McHugh.

LINDEROTH, L. SIGFRED, JR., Professor of Mechanical Engineering, Iowa State College, Ames. Ia. F. Kerekes, J. F. Downie-Smith.

MAGUIRE, JACK H., Instructor in Civil and Architectural Engineering, University of Colorado, Boulder, Colo. C. L. Eckel, H. H. Kelly.

MAJOR, COLEMAN J., Associate Professor of Chemical Engineering, University of Iowa, Iowa City, Ia. K. Kammermeyer, F. M. Dawson.

MALCOLM, DONALD G., Assistant Professor of Mechanical Engineering, University of California, Berkeley, Calif. A. S. Levens, E. C. Keachie.

MERKLEY, CHARLES N., Associate Professor of Woodwork and Building Construction, Utah State Agricultural College, Logan, Utah. J. Conlam, F. Preator.

MERRIAM, ROBERT W., Instructor in Electrical Engineering, Swarthmore College, Swarthmore, Pa. H. M. Jenkins, W. I. Reaser.

MOSHER, RAYMOND F., Associate Professor of Electrical Engineering, University of Vermont, Burlington, Vt. L. F. Shorey, H. M. Smith, Jr.

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PAINTER, WILLIAM D., Assistant Professor of Civil Engineering, University of Tennessee, Knoxville, Tenn. L. R. Shobe, C. R. Ownbey.

PLATT, EDWARD K., Assistant Professor of Engineering Drawing, Michigan State College, East Lansing, Michigan. O. W. Fairbanks, D. M. Fullmer.

REESE, LYMON CLIFTON, Assistant Professor of Civil Engineering, Mississippi State College, State College, Miss. D. M. McCain, E. D. Myers.

ROBERTS, J. KENT, Assistant Professor of Civil Engineering, Missouri School of Mines and Metallurgy, Rolla, Mo. V. A. C. Gevecker, L. Hershkowitz.

ROLLINS, JOHN P., Assistant Professor of Mechanical Engineering, Clarkson College of Technology, Potsdam, N. Y. E. McHugh, M. G. Mochel.

RUSSELL, LILY L., Director, Placement Center, University of Houston, Houston, Texas. L. J. Castellanos, W. B. Lowe.

SCOTT, NORMAN R., Assistant Professor of Electrical Engineering, University of Connecticut, Storrs, Conn. L. E. Williams, G. Timoshenko.

SCOTT, RONALD E., Instructor in Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. E. Tucker, K. L. Wildes.

SHAW, G. MERRILL, Assistant Professor of Metalwork, Utah State Agricultural College, Logan, Utah. J. E. Christiansen, F. Preator.

SHILLING, GEORGE D., Assistant Professor of Engineering, Kansas State College, Manhattan, Kansas. A. O. Flinner, H. T. Ward.

SHIRLEY, JOHN W., Dean, Basic Division of the College, North Carolina State College, Raleigh, N. C. J. H. Lampe, J. W. Harrelson.

SKILLING, HUGH H., Professor of Electrical Engineering, Stanford University, Stanford, Calif. E. Grant, D. H. Young.

SNYDER, NORMAN F., Senior Teacher, Engineering Section, General Motors Institute, Flint, Mich. H. M. Dent, L. C. Lander.

STEIN, ROBERT, Assistant Professor of Electrical Engineering, City College of New York, New York, N. Y. C. Froelich, H. Wolf.

STEEK, ROBERT P., Instructor in Petroleum Engineering, University of Houston, Houston, Tex. L. J. Castellanos, W. B. Lowe.

STRAIGHT, D. ARTHUR, Lecturer, Management and Personnel, Newark College of Engineering, Newark, N. J. C. H. Stephans, F. N. Entwisle.

STRAIT, JOHN M., Instructor in Engineering, Eastern New Mexico University, Portales, N. M., R. S. Paffenbarger, C. E. MacQuigg.

SULLIVAN, THOMAS M., Engineer of Airports, Port of New York Authority, New York, N. Y. W. S. LaLonde, J. M. Robbins.

SWENSON, DAN H., Instructor in Woodwork, Utah State Agricultural College, Logan, Utah. J. E. Christiansen, F. Preator.

SZEGO, GEORGE C., Assistant Professor and Head, Chemical Engineering, Seattle University, Seattle, Wash. O. M. Klose, C. F. Gerald.

THIBODEAUX, MURPHY H., Instructor in Civil Engineering, The Rice Institute, Houston, Texas. L. B. Ryon, M. R. Marsh.

THOMSON, CHRISTIAN R., Instructor in Radio, Waite High School, Toledo, Ohio. W. G. Rohr, W. F. Rohr.

TUTTLE, MILTON A., Associate Professor of Ceramic Engineering, North Carolina State College, Raleigh, N. C. W. W. Kriegel, K. P. Hanson.

WILSON, WILLIAM H., Instructor In Engineering Drawing, Case Institute of Technology, Cleveland, Ohio. O. M. Stone, H. R. Young.

WORK, CLYDE E., Instructor in Theo. and Applied Mechanics, University of Illinois, Urbana, Illinois. W. M. Lansford, W. E. Black.

WRIGHT, HAROLD E., Instructor in Mechanical Engineering, University of Dayton, Dayton, Ohio. J. H. Parr, A. R. Weber.

WRIGHT, WILLIAM F., Assistant Professor of Mechanical Engineering, Vanderbilt University, Nashville, Tenn. B. M. Bayer, C. H. Bonney.

178 new members this year

ECPD News

(*Continued from 191*)

various community organizations; third with the employer; and fourth with the young engineer himself. Business and service groups were also urged to develop organized programs to welcome newcomers. "Integrating the young engineer into his community will remain a problem only so long as it is a neglected problem. Only a little thought given to its solution in each community will lead to an effective program," the committee concluded.

The fourth part of the volume dealt with engineering registration laws. The viewpoint of the E.C.P.D. committee was that legal recognition does not constitute professional maturity, but rather represents a minimum requirement for engineers. Full professional development depends on continued study and practice of engineering with recognition of responsibility to associates, employer and the public. The committee places on the shoulders of the engineering societies the responsibilities for providing inspiration to carry individuals far beyond the minimum standards of education and experience which are set by the state.

The final part of the study concerns methods and sample tests to help the young graduate make a self-appraisal of his qualifications so that he can redirect himself to take advantage of the opportunities offered.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 1, 1951 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President .....
(In Charge of Sections and Branches—two years)

.....

For Treasurer .....

.....

Signed .....

Title .....

Institution .....

Date .....

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute	April, 1951	D. F. Miner Carnegie Institute
Illinois-Indiana	Purdue University	May 20, 1950	D. S. Clark, Purdue University
Kansas-Nebraska	Kansas State College	Oct. 13–14, 1950	F. W. Norris, University of Nebraska
Michigan	General Motors Institute	May 20, 1951	H. M. Dent, General Motors Institute
Middle Atlantic	Stevens Institute of Technology	Dec. 9, 1950	C. H. Willis, Princeton University
Missouri	Missouri School of Mines	April 1, 1950	C. M. Wallis, University of Missouri
National Capital Area	Naval Ordnance Laboratory	Oct. 3, 1950 Feb. 6, 1951 May 12, 1951	R. B. Allen, University of Maryland
New England	University of New Hampshire	Oct. 14, 1950	W. C. White, Northeastern University
North Midwest	University of Minnesota	Oct. 6 & 7, 1950	C. J. Posey, University of Iowa
Ohio	Ohio State University	April 29, 1950	S. R. Beitler, Ohio State University
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	Stanford University	Dec. 28 & 29, 1949	R. J. Smith, San Jose State College
Southeastern	Buena Vista Hotel	March 22, 23, 24, 1951	E. B. Norris, Virginia Polytechnic Institute
Southwestern	Texas A. & M. College	April, 1950	W. H. Carson, Oklahoma University
Upper New York	University of Buffalo	Oct. 13 & 14, 1950	F. H. Thomas, University of Buffalo

Members of the Society are welcome at all Section Meetings

Annual Meeting

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